



28 April 2017

The Hon. Justice Pepper  
Hydraulic Fracturing Taskforce  
GPO Box 4396  
Darwin, NT 0801, Australia

The Honourable Justice Pepper,

**RE: Submission to the Scientific Inquiry into Hydraulic Fracturing of Unconventional Reservoirs Onshore within the Northern Territory**

Origin is pleased to submit the attached response to the Terms of Reference and Background and Issues Paper of the Scientific Inquiry into Hydraulic Fracturing of Unconventional Reservoirs (the Inquiry). Attached are the following:

1. Origin's submission
2. Appendix 3 data (groundwater monitoring data)
3. Appendix 8 data (Pennsylvania regulator database)

A tabulated summary of specific questions posed by the panel to Origin, during the public consultation meeting in Darwin, is included with this letter. The table includes responses that are primarily references to the relevant sections of our submission. If you or any member of the Inquiry Panel have any further questions or require clarification on any aspect of our submission, please don't hesitate to contact myself or our Corporate Affairs Manager for Northern Australia, [REDACTED]

Yours faithfully,

A handwritten signature in black ink, appearing to read "D. Close".

David Close  
Chief Geologist  
Origin  
[REDACTED]

**Inquiry Panel questions and requests (from Origin’s appearance on 20 March at the Darwin Public Meeting)**

#	Question/Request	Response
1	Can Origin provide the baseline groundwater data acquired since 2014?	Yes, the data are summarised in Appendix 4 and a full copy of the data provided electronically.
2	Regarding chemicals in fracture stimulation fluids, what do you mean by public disclosure? What about issues with commercial in confidence materials?	Origin’s disclosure to the regulator and a discussion of intellectual property regarding fracture stimulation fluid technology are both included in Chapter 4.3.
3	There is widespread skepticism about legacy issues from large scale development and well integrity being adequately dealt with, does Origin have any comments?	Well integrity and abandonment (Chapters 4 and 13), are discussed within our written submission. Origin maintain that at the end of the project it must be shown that there is no long term liability for the Northern Territory Government, and at that point abandonment is complete.
4	US studies have shown that 6-7% of wells fail, what is Origin’s experience and interpretation of these studies?	Well integrity and well failure rates, and studies such as the US EPA study, are discussed in Chapters 4 and 13. There are no credible data that suggest a failure rate, where there is any kind of release to environment, which is above a fraction of a percent.
5	The US EPA has reported that drinking water has been contaminated by fracture stimulation activity, so why does Origin state that there have been no instances of contamination from hydraulic fracturing?	The US EPA study and findings are discussed in Chapter 13.
6	What does Origin mean by ‘acceptable risk’?	A discussion of Origin’s approach to risk management is included in Chapter 2.
7	Can insurance be obtained for fracture stimulation activities and are the landholders covered?	Yes, insurance has been included in all Origin’s land access agreements in the Northern Territory to date. Each agreement that has been finalised with a landholder has been reviewed by the landholder’s independent legal advisors.
8	How informed and representative was the agreement reached with Traditional Owners given that one voice doesn’t speak for all - are you confident of lasting benefits?	Origin has followed the process prescribed under NT and Commonwealth legislation to engage the Northern Land Council and Traditional Owners in the Beetaloo region.
9	What area of land is impacted by the notional development scenario shown by Origin?	Land utilisation is covered in Chapter 3 and Chapter 14.
10	Will developing new gas resources mean a	The Australian Energy Market Operator’s

	delay in shift to renewable energies?	latest Gas Statement of Opportunities begins with the statement: “Gas-powered generation is vital to continued security of electricity supply as the National Electricity Market transitions to lower emissions targets.” Gas has a critical role to play in a low-emissions future as both a replacement for coal and a partner for renewables.
11	How can the Northern Territory avoid or minimise “boom/bust” cycles and who should be charged with responsibility for this?	This question is discussed in Chapter 3.
12	Does Origin consider the current legislation and regulations are suitable for an unconventional gas industry?	The current Petroleum Act (2016) and associated regulations are more than adequate for the level and type of activity underway and proposed for the short- and medium-term in the NT. Origin agrees reforms are necessary in the longer term, however, these are not required for environmental protection rather for efficient regulatory operations.

# SUBMISSION TO THE

SCIENTIFIC INQUIRY INTO  
HYDRAULIC FRACTURING IN  
THE NORTHERN TERRITORY

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**30 April 2017**





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## FOREWORD

Origin welcomes the opportunity to contribute to and participate in the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory (the Inquiry). The Inquiry Terms of Reference (TOR) are focused on assessing the “...scientific evidence to determine the nature and extent of the environmental impacts and risk, including the cumulative impacts and risk, associated with hydraulic fracturing...”. Oil and gas operators, such as Origin, are fluent in the language of science, engineering and risk assessments. A purely scientific focus on obtaining public acceptance of hydraulic fracturing, however, has met mixed success. We fully support the expanded scope that the Inquiry’s Background and Issues Paper introduces, which includes issues of socio-economic impacts and land access.

Through our history of exploring and developing oil and gas resources across Australia and particularly through our role as the upstream operator of the Australia Pacific LNG (APLNG) project in southwest Queensland and the Beetaloo Project in the Northern Territory, we have found that embracing coexistence with landholders and communities is just as critical to success as good science and engineering. We believe that coexistence can – and already does – happen, and there are hundreds of examples across Australia where this is demonstrated. It is important that landholders and Traditional Owners are fairly compensated for sharing access to their land and accepting the principle of coexistence. In Queensland, Origin has committed around \$400 million to date to the first 100 landholders involved in the Australia Pacific LNG Project that Origin operates. Above and beyond compensating for impacts, Origin aspires to innovate with landholders and communities to the mutual benefit of both industries.

Origin has a strong record of drilling and hydraulic fracturing in Australia; this record along with our standards and processes for risk assessment, risk mitigation, and where possible, risk elimination, give us the confidence to state that we can develop unconventional gas in the Northern Territory while also preventing unforeseen impacts to the environment. The Inquiry recognises that protecting water resources is critically important, and this aligns with our experience from community consultations. The protection of water resources, from contamination events and from over-use, is almost always the first issue raised by people we speak to who have concerns relating to hydraulic fracture stimulation.

The key to protecting water from contamination is designing and constructing a well that has the integrity to isolate material within the well from the environment for the life of that well, until it is permanently plugged. Industry’s record on well integrity is good, both in Australia and internationally, particularly with modern well completion techniques under modern regulatory regimes. Although the likelihood of a well failure or contamination event is remote, they can be highly visible and high impact when they do occur. Both acute events, such as well blowouts, and chronic issues, such as long term well liabilities, provide stark reminders that our industry must continuously assess and manage risks on short and long time frames.

Risk management in the resources sector has seen safety and environmental performance improve systematically over recent decades, and we strive for ongoing improvement. The barriers Origin puts in place to ensure well integrity and protect water quality are robust, and are always verified. In the context of hydraulic fracture stimulation of Northern Territory’s deep shale gas resources, such as in the Beetaloo Basin, it is well integrity that is relevant to preventing water contamination; the prospect of induced fractures growing from the shale gas targets to potable aquifers and providing pathways for contamination is not physically feasible.

Managing water allocation is also critically important to ensure that sufficient annual recharge is reserved for the unique, natural environment of the Northern Territory. The water requirements of an unconventional gas development in the Northern Territory cannot be forecast in detail at this early stage of exploration, however, the water that is required must be accessed and used such that other existing, or new and growing, industries are not adversely impacted. Based on the data available, which span decades, there is no feasible scenario where there would be water use conflict in the Beetaloo Basin region of the Northern Territory, where Origin operates, due to the large storage and prolific annual recharge of the Cambrian Limestone Aquifer in this region.

Our activities often impact our landholders' businesses and lifestyles. We take steps to prevent or avoid such impacts. Where they are unavoidable, we listen to landholders to understand how we can work together to minimise the impacts on them. We also compensate for all financial losses as well as personal impacts, such as the loss of privacy or amenity, and we remediate as we complete our works. Relationships and trust with our host Traditional Owners and pastoralists are important to Origin, and are at the heart of successful coexistence. We are open, transparent and consultative with our stakeholders and earn their trust by saying what we will do, and doing what we say.

In the Northern Territory we are still building these relationships, developing a track record of successful consultation, negotiation, compensation and activity. We know that co-existence is a proven proposition, we experience it in southwest Queensland every day. Origin believes the obligation of coexistence applies to landholders also, and does not support the creation of a landholder access veto. Government, not an individual landholder, should have the ultimate right to decide whether the nation's energy resources are developed for the public good.

We consult with our Traditional Owners to ensure we avoid areas of cultural significance in our activities. We work with our landholders to ensure that our activities complement their existing businesses and allow them to achieve their business goals. This is attested to by the fact that of the first 100 landholders for the APLNG project with gas infrastructure on their land, 100% are still using their land for farming and grazing purposes – a further demonstration that coexistence can and does occur.

Beyond directly impacted stakeholders, Origin has sought to work with communities in which we operate. Being part of the community as well as supporting long term regional development is necessary to achieve this; the Northern Territory offers unique challenges and opportunities in this context. Origin's permits are located almost equidistant between the towns of Katherine and Tennant Creek, close to the small communities of Elliot and Daly Waters; this creates challenges in terms of the limited existing services, but huge opportunity in the scope for economic growth and opportunity for the region.

The full potential of unconventional gas resources in the Northern Territory requires further evaluation to be understood in detail. Early exploration results in the Beetaloo Sub-basin of the Sturt Plateau and Barkly Tablelands region have, however, been positive. Origin has drilled four wells since 2015, including the first horizontal well in the Basin. In 2016 we successfully fracture stimulated that horizontal well and completed an extended production test. The data from this test underpin the 6.6 trillion cubic feet (TCF) contingent resource booking announced by Origin in February 2017. 6.6 TCF is equivalent to over five years of Australia's domestic consumption, a significant discovery.



Although a substantial resource has been recognised in the Beetaloo already, there is the potential to grow the contingent resource with further exploration drilling and convert the contingent resources to reserves with appraisal drilling and extended testing. If the gas can be produced economically, the Beetaloo could provide long-term gas supply security for the Australian domestic gas market, and support Australia's gas export infrastructure in the Northern Territory and Queensland. There are not many opportunities such as this left in onshore Australia, further increasing the importance of this discovery and of the Northern Territory's position on onshore gas development.

This submission includes evidence and discussion of potential impacts and benefits for the Northern Territory based primarily on the Risk Themes identified in the Background and Issues Paper. A potential development scenario, based on data from our exploration campaigns in 2015 and 2016, is defined to provide specific examples to the discussion of risks and controls. For example, we estimate that one to four landholders would have development wells on their properties as a result of this scenario, compared to the hundreds of landholders who have wells in the more densely populated and farmed Surat Basin in Queensland.

Origin's exploration campaigns provide an example of how exploration and appraisal activities can be managed under the current Petroleum Act and associated regulations, which provide stringent checks and regulatory oversight. Continuing exploration and appraisal while any legislative reform suggested by this Inquiry is undertaken is an appropriate way forward, to ensure a viable industry can evolve and that data and experience critical to future success can be gained.

There will be challenges to overcome in bringing gas from the Beetaloo to market, and the first step towards this is lifting the current moratorium on hydraulic fracturing. The opportunity for the Northern Territory, Australia's gas users, and also Origin and its shareholders if we can do so is substantial and can yield multiple public benefits. The direct economic stimulus in the region and the opportunity to ensure gas supply security for Australian manufacturers are foundational reasons that Northern Territory's gas potential must be reached. But more importantly, gas-powered generation is vital to the security and affordability of electricity supply as the Australian electricity market transitions to lower emissions energy sources.

A handwritten signature in black ink, appearing to read "Mark Schubert".

**Mark Schubert**

Executive General Manger, Integrated Gas  
Origin

# 1 INTRODUCTION

## 1.1 About Origin

Origin Energy (ASX: ORG) is the leading Australian integrated energy company with market leading positions in energy retailing (approximately 4.2 million customers), power generation (more than 6,000 MW of capacity owned and contracted) and natural gas production (1,204 PJe of 2 Preserves and annual production of 75 PJe). Through Australia Pacific LNG, its incorporated joint venture with ConocoPhillips and Sinopec, Origin has developed one of Australia's largest unconventional gas to LNG projects based on Australia's largest 2P Coal Seam Gas reserves base.

Origin has the longest track record of any major unconventional gas company in Australia, having drilled our first unconventional gas exploration well in Queensland in 1993. For over 20 years we have been working with local communities to gain access to unconventional gas resources. The benefits from unconventional gas development for regional growth and infrastructure development are pronounced. Gas also delivers broader benefits as an important transition fuel to a lower carbon future.

Origin aspires to be the number one renewable and low carbon energy company in Australia. Origin is one of the largest installers of domestic solar electricity capacity in Australia, having directly installed about 90,000 systems to date. In total, about 400,000 of our retail customers have solar products. Last year, Origin launched a new solar leasing product, which allows more customers to access the benefits of solar without having to purchase the system. We are also exploring new opportunities to invest in utility scale solar projects.

## 1.2 Origin's Commitments and Principles

At Origin our Compass, which includes a number of Commitments and Principles, guides our choices. The development of energy can create trade-offs between the sometimes conflicting, but not necessarily mutually exclusive, challenge of having a reliable, affordable and sustainable supply of energy for Australia while minimising environmental and social impacts to our host communities. We know, however, that coexistence between community and gas development is possible, because we have done and are doing it – this will always be our aim.

The development of gas provides significant economic benefit to Australia and the communities in which the development occurs. These benefits come in the form of jobs, economic growth, government revenue and lasting infrastructure development. The development of gas increases the available supply to meet the increasing demand for gas in Eastern Australia and globally. These benefits serve our commitments to our customers, shareholders, business partners and the wider communities in which we operate.



We also support the safe and responsible development of gas and a robust, science-based regulatory framework for the industry. Origin has systems and procedures to ensure that we meet our legislative requirements in relation to health, safety and the environment. We also strive to adopt innovative processes which reduce our footprint and seek to provide better protection for the environments in which we operate. We are transparent about our business so that communities can assess for themselves how we are doing, and we listen to their feedback. This speaks to the commitments we make to the rights and interests of our local communities.

Policy frameworks that assist industry and government to improve how we work with landholders and communities are critical to strengthen our social licence to operate and build sustainable relationships.



### OUR COMPASS

Our Compass guides how we do things. It sets out our purpose and guides the decisions we make, the actions we take and the behaviours we display as an organisation.

Our Compass is how we refer to our Purpose, Values, Principles, and Commitments.

<h4>OUR PURPOSE</h4> <p>We aspire always to lead.</p> <p>We deliver today's energy needs, and we search and innovate to create tomorrow's energy solutions.</p> <p>We honour our Principles and Values, and they are evident in all we do.</p> <p>We live our Commitments to our shareholders, to our customers, to our people, to our communities and to our business partners.</p>	<h4>OUR PRINCIPLES</h4> <p>Our Principles help to guide us in making the right decisions. They are listed in the order we apply them.</p> <p>We conduct ourselves and our business with <b>due care</b> and in accordance with relevant laws and regulations. We have an overriding duty to ensure the health and safety of our employees, and to minimise the health, safety and environmental impacts on our customers and the communities in which we operate.</p> <p>We will <b>add value</b> to the resources that come under our control.</p> <p>The value we create will be distributed to stakeholders, recognising the need to ensure the <b>sustainability</b> of our business, and its impact on the environment and the communities in which we operate.</p> <p>We encourage <b>diversity</b> and expression of ideas and opinions but require <b>alignment</b> with the Company's Principles, Values and Commitments and the policies established to implement them.</p> <p>When faced with choices, we make decisions knowing they will be subject to <b>scrutiny</b>. We should be able to demonstrate the soundness of our decisions to all stakeholders.</p> <p>Our Code of Conduct outlines governing aspects of our duty of care and can be found online.</p>	<h4>OUR COMMITMENTS</h4> <p>Our Commitments define the outcomes we strive to achieve for key stakeholders. We commit to:</p> <p>Deliver market-leading performance for <b>shareholders</b> by identifying, developing, operating and growing value-creating businesses.</p> <p>Create value for our <b>customers</b> by understanding their needs and delivering relevant and competitive energy solutions to meet those needs both today and into the future.</p> <p>Create a rewarding workplace for our <b>people</b> by valuing everyone's contribution, encouraging personal development, recognising good performance and fostering equality of opportunity.</p> <p>Respect the rights and interests of the <b>communities</b> in which we operate, by listening to them, understanding and managing the environmental, economic and social impacts of our activities.</p> <p>Respect the rights and interests of our <b>business partners</b> by working collaboratively to create valued and rewarding partnerships.</p>
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### 1.2.1 What our landholders say about us

The best way for us to demonstrate how coexistence can work for landholders and Origin is to share the experiences of two landholders from southwest Queensland, where Origin have been actively developing gas fields for over a decade. Our time in the community in Queensland has allowed strong, trusting relationships to develop, as the following testimonials illustrate.

### Land owner experience – Brett Griffin

*My name is Brett Griffin, a third generation Yuleba grazier.*

*With my wife Di, I run cattle on our 16,000 acre forest grazing block north-west of Miles in Queensland's Surat basin. We have two sons Harley, 29 and Hamish 24. We have 128 coal seam gas (CSG) wells on our property and after initially being a reluctant participant I have seen the benefits that have flowed to us and as a result have changed my views. This was helped by the way Origin has fostered good relations, not only with me, but with other landowners. I look at it this way. Gas chooses you, you don't choose it. So it's a shock when it comes. We are all divided into three groups. Active participants, reluctant participants and conscientious objectors.*

*But the thing about that is you can change camps as time goes by.*

*I would have kicked off in the reluctant end of reluctant participant but as I saw the benefits of what came on here and what we were able to do and we went from struggle street to a complete turnaround I'd be an idiot if I didn't change my view. Right at the start I made a point of learning as much about the industry as I possibly could so that I was in a position to negotiate with knowledge. At first, negotiations were put under pressure when one gas company employee would agree to something that was never delivered. That all changed when Origin appointed a full time company contact which signalled the turning point in my relationship with Origin. I'm told it was the same for other landowners.*

*It's all about cooperation. Once we had agreed to the drilling of wells on our property Origin went to a lot of trouble to minimise disruption. And there was a lot to deal with. Early on I counted 250 vehicles a day going through my front gate – all associated with Origin. First thing they did was the roads. It was a massive development on the roads. I opened a gravel pit and we sold gravel. They used that gravel to do the roads and they put security guards at the mailbox and everybody had to sign in and sign out and be accounted for. But that wasn't all. I was able to negotiate a number of additional things that have been a benefit to our company. A big positive was being able to set up my sons in a water trucking business supplying the gas industry in the area. It has grown quite amazingly and the boys are flat out and now employ a number of locals.*

*Another example of cooperation involved 1000 tonne of rubble that Origin had and were faced with dumping it in Roma. We were able to negotiate to use that rubble on our property...we were doing each other a favour. Then there was water. They have to get water to places. I talked to them about this because it was drought time. I was faced with putting in a lot of infrastructure which was hideously expensive. They needed to get water so we worked together to the benefit of both of us. It was fantastic what happened.*

*Then there was a big fire which was going to cost both me and my neighbour a lot of money owing to damage caused to people and equipment working on our properties. Origin stepped in and took care of it all. You can make things work with a good relationship. My relationship with Origin has developed over the years. We are totally up front with each other. We work, I wouldn't say as partners, but we coexist on a pretty good basis. It's a good relationship.*

*When I went to Curtis Island for celebrations for the first international export for Australian Pacific LNG I was struck by just what a big operation it is. It is quite obvious that it has created a lot of work for a huge number of people. That's what I think about. It's massive and to have got that off the ground is a pretty big thing.*

### Landholder experience – Simon Drury

*My name is Simon Drury and along with my wife Kylie and four sons we own and operate a five and a half thousand acre property called Condabri on the Condamine River between the towns of Miles and Condamine on Queensland's Western Downs. We are a family-run business, comprising a 5000-head feedlot and 500 acres of crops including wheat, barley, sorghum and corn.*

*We supply grain-fed beef to the domestic and international markets under our Condabri Beef label.*

*Over the past 20 years Condabri has developed into a highly intensive industry and now coexists successfully with another highly intensive industry involving the piping of coal seam gas (CSG) from beneath our land throughout Australia and the world. It is a most successful partnering which has benefitted all involved including my family, our Condabri property, our neighbours, the surrounding district and, of course, Origin Energy. Since we were first approached by Origin in 2009 to establish a small pilot project of four test wells aimed at proving the viability of the gas field we have met and dealt with many challenges as a family.*

*Today, we have around 50 wells operating on our land with many a benefit for us. Our sons Lachlan 24, Will 21, Tim 18 and Tommy 13, now have a future out here without being forced to chase jobs hundreds of miles away. Lachlan and Will work on Condabri, Tim is an apprentice diesel fitter at nearby Dalby while Tommy is still at school in Brisbane and can't wait to come back and work with me, Kylie and his brothers. It's a scenario that is shared by countless families in our area as well as many more where the landowners have embraced CSG. At the start neighbours queried my wisdom of embracing CSG on our property but now the queries are about how CSG could benefit them. I can't over emphasise the good that has come about as a result of the CSG industry up here.*

*When Origin first came to us with a plan for 50 wells a couple of years after the test wells we had input into where most of them would be sited. We put them behind shade lines, we put them in corners of paddocks and we put them wherever we thought they wouldn't be in the way.*

*Origin was very flexible.*

*Another illustration of their flexibility came after the 2010-2011 flood which caused havoc and we had to build a new house on higher land. There was a well planned for where we wanted to build and after being told, Origin relocated it 700m away from the new home. It's a big deal to change sites but Origin did it. Then the drilling started. It's a big deal to put wells down and bores down and pipes and that sort of things. Back then the contractors were relatively new at it and it would take them four days to drill a well. Now they are down to one a day. The process is very streamlined and quick now. And wells are quieter, being operated on electricity instead of diesel. Then there is the water which is a real bonus. Potable water is basically a by-product of CSG. We now have access to more water than before the wells and of better quality.*

*What really upsets me is much of what they are portraying on the radio and the newspapers in opposition to CSG is simply not true. Like here on the gas fields. When it's done and developed you wouldn't even know they were there. And it's another passive income in our business and it has helped hundreds and hundreds of farmers. It did not come easy. At the start we had a difficult task of working out a fair conduct and compensation package but once again, with goodwill we worked it out to everyone's satisfaction. It is also fascinating to see how our gas was being converted and exported. Hopefully it might just stop another tonne of coal being burnt.*

### **1.2.2 Natural gas**

Natural gas, including shale gas, is an abundant, affordable, flexible, easily transportable, low carbon fuel that has a critical role to play in Australia and globally in meeting ambitious climate change targets. As the population continues to grow, and nations seek to better living standards for their citizens, the demand for energy will increase. The most recent International Energy Agency Outlook 2016 forecasts that gas usage will experience considerable growth over the next 50 years.

Over this time, Australia and the world will look for cleaner fuel options as we transition to a low or zero carbon economy. When used for electricity generation, natural gas produces less carbon emissions than coal and is widely acknowledged as an ongoing complementary fuel to support the intermittency of renewables. The USA, for example, has reduced CO<sub>2</sub> emissions from electricity generation to 1990 levels since 2008 as the utilisation of natural gas, primarily from fracture stimulated shales, has increased and displaced coal as a source of baseload power (EIA, 2017).

It is also important to ensure that gas is supplied at an affordable price whilst balancing the needs of landholders, local communities and Traditional Owners and maintaining environmental safeguards. Origin recognises that these are complex and interrelated issues and is committed to working with stakeholders to ensure that the Northern Territory and Australia have a sustainable gas industry.

Origin's diverse business brings us into contact with a range of people and how we approach and build relationships over time is important. We believe that co-existence can – and already does – occur successfully. The most relevant demonstration of this is how our work to date in the Northern Territory (NT) including hydraulic fracture stimulation (HFS) has been experienced.

### **1.3 Origin's upstream experience**

Origin has a long history of onshore gas development. This has included the safe and compliant HFS of over 200 wells since 2000, predominantly in Queensland, without issue or incident. Origin has worked with the Queensland Government during that time to develop and mature the regulatory framework that governs the State's hydraulic fracturing operating and reporting requirements.

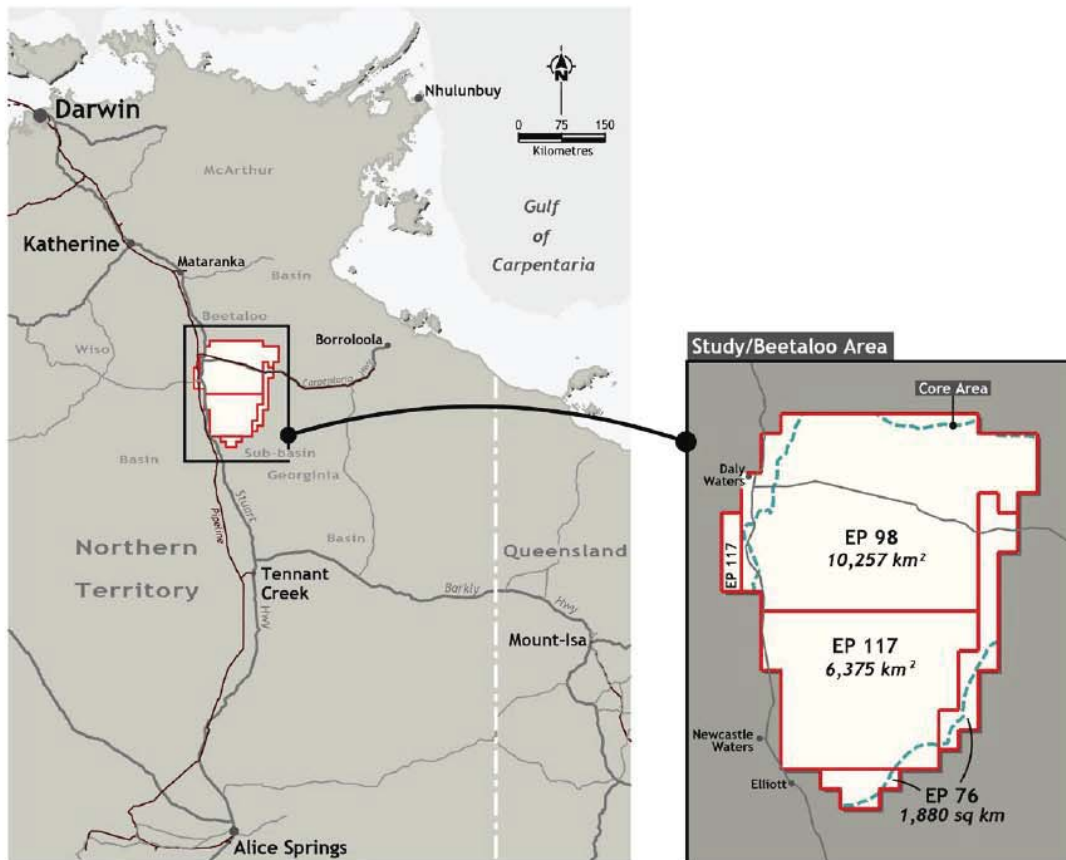
Reflecting on our wider operating experience of over 20 years, Origin has engaged with communities and landholders and worked across Australia's States and Territories to explore, develop and produce gas. Origin is also the upstream operator of the Australia Pacific LNG project in Queensland where we have worked hard to successfully establish a model where our gasfield development can co-exist with the grazing and more intensive agriculture operations of our landowners.

We ensure that multiple land uses can occur at one time. We consult with our landholders to make sure that our activities complement their existing business and we work with them to achieve their business goals. Of our first 100 landholders for the Australia Pacific LNG project with gas infrastructure on their land, 100% of them are still using their land for farming and grazing purposes. This is a clear demonstration that co-existence does occur. Also, a recent independent market analysis (Taylor Byrne, 2016) has shown that the growth in the value of properties in the regional areas of Queensland where there is gas development has exceeded growth in the surrounding regional areas.

In co-existing, Origin seeks to work with the communities in which we operate. Being part of the community as well as supporting long term regional development is fundamental to achieving this. For example, Origin has implemented a 'Living Local' program which incentivises our employees to live within regional communities. We also source contracts from regional suppliers and to date, Australia Pacific LNG has invested \$46.1 million dollars in the communities in which we operate. As part of the project, we have also upgraded major infrastructure such as roads and airports and established health and education facilities.

### 1.4 Origin's NT operations

In May 2014, Origin announced a farm-in to EP98, EP117 and EP76 (the Permits) held by Falcon Oil & Gas (Falcon) in the Beetaloo Basin<sup>1</sup> (Beetaloo) of the NT (Figure 1). Through the farm-in Origin and Sasol, which also farmed in, have the option to earn 35% equity in the Permits, which cover over 18,500 km<sup>2</sup> of prospective acreage in the core area of the Beetaloo. Origin, as operator of the Beetaloo joint venture, has been progressing a multi-year exploration program over the Permits with four wells drilled over 2015 and 2016, including the first horizontal well in the Beetaloo.



**Figure 1.** Geography of the Permits, operated by Origin since 2014.

1 This geological region equates to the Beetaloo Sub-basin as published by the Northern Territory Geological Survey (Ahmad and Munson 2013)

The Permits are currently in their first renewal term of five years, having been renewed on 1 January 2014. The Permits were originally granted in 2001 (EP76), 2004 (EP98) and 2007 (EP117), in an area where exploration permits have been intermittently held and exploration activities such as drilling and seismic surveying have been undertaken since 1984. The work program commitments associated with the current renewal term include nine wells over five years, six of which include HFS (Figure 2).

## 5 YEAR WORK PROGRAM

31 March 2017

EP	STAGE 1			STAGE 2	STAGE 3
	2014	2015	2016	2017	2018
<b>98</b>	Geological and geophysical studies	2 vertical wells, 1 horizontal well	1 HFS vertical well 1 HFS horizontal well	Geological and geophysical studies, core studies	2 HFS horizontal wells Production testing Geological and geophysical studies
<b>117</b>	Geological and geophysical studies	Geological and geophysical studies	1 vertical well	2 HFS horizontal wells Production testing Geological and geophysical studies	Geological and geophysical studies
<b>76</b>	Geological and geophysical studies	Geological and geophysical studies	Geological and geophysical studies	Geological and geophysical studies	Geological and geophysical studies

\*HFS  
Hydraulic Fracture Stimulation

**Figure 2.** Work program commitments as defined by the conditions of the Permits. Note that due to the introduction of the moratorium on hydraulic fracture stimulation in 2016 the Year 3 (2016) program is partially complete (one fracture stimulated vertical well on EP98 remains to be completed).

Origin's exploration program in the Beetaloo is focused on proving the potential of shale gas in the Mesoproterozoic source rocks of the Roper Group, primarily the Velkerri and Kyalla formations. The term shale gas refers to gas produced from fine-grained, gas-bearing sedimentary rocks with low permeability and high organic content (Lakatos and Szabo, 2009). To evaluate shale gas plays effectively requires that the target formations are fracture stimulated, as without fracture stimulation shale gas is not producible and cannot, therefore, be tested for commerciality.

Origin's exploration program has provided positive early results, however, substantial further appraisal is required to determine whether a commercial development is viable. Although it is still uncertain whether Origin's discovery in the NT will be commercial, results to date are sufficient to confirm that the magnitude of the discovery, if it is commercial, is sufficient to supply both domestic and export markets. Given the existing LNG export capacity in both Darwin (Darwin LNG and Ichthys) and Curtis Island, Queensland (GLNG, APLNG and QCLNG), it is unlikely that any greenfield liquefied natural gas (LNG) export capacity will be required to commercialise a Beetaloo discovery.



## 1.5 Structure of this submission

This submission is structured to reflect the Risk Themes identified in the Background and Issues Paper (Issues Paper) published by the Inquiry on 20 February, 2017, as well as to provide further context, evidence and data.

**Chapter 2** addresses Origin's approach to risk management, and where appropriate discussion of general or best practice in the extractive resources sector.

**Chapter 3** provides a summary of Origin's activity in the Beetaloo over 2015 and 2016 and describes a potential development scenario in practical terms. This provides a fact base for the subsequent risk discussion that is specific to the permit area and the small subset that would be disturbed for a potential future development.

**Chapters 4 through 12** refer both to specific data relevant to the Beetaloo potential Development Area (as defined in Chapter 3) and to principles that hold regardless of geography. Each chapter begins with a statement of Origin's overall approach to and beliefs about the risk. Much of the content regarding drilling and HFS is specific to Amungee NW-1 and Amungee NW-1H (also defined in Chapter 3).

**Chapter 13** discusses well integrity principles additional to those covered in Chapter 4.

**Chapter 14** describes the geology of the Beetaloo, which sets the nature and extent of many of the risks assessed in Chapters 4 to 12.

**Chapter 15** addresses specific concerns and issues that we hear raised consistently by concerned people and/or industry opponents.



## 2 RISK MANAGEMENT

### 2.1 Assessment and mitigation

The Issues Paper identifies nine Risk Themes that may be linked to unconventional gas development. Origin's submission addresses the specific details of these risk themes in turn. This section explains Origin's principles and processes for managing risk in order to achieve the following key outcomes:

- Risks are understood, eliminated or reduced and controlled to an acceptable level.
- Controls are owned, assured and continuously reviewed for effectiveness.
- All activities are compliant with regulatory standards and are guided by best practice, and
- Origin and its stakeholders are confident in the way activities are conducted to manage risks.

All activities entail a degree of risk of an unwanted event. However, assessing the combination of frequency of occurrence and the severity of the outcome of an unwanted event allows quantification of the risk and a determination made about whether the risk can be accepted, or whether further mitigation is required. Origin uses a risk matrix (Figure 3) to assess and rate risks.

## Risk Matrix

		IMPACT ON ORIGIN OPERATIONS			EXTERNAL RESPONSE			
		Conduct Business with Due Care	Create Value		Decisions are Subject to Scrutiny			
		People	Environment and Community	EBIT	Cash flow	NPV	Stakeholder Perceptions	Laws, regulation and civil actions
CONSEQUENCE	6 CATASTROPHIC	Multiple fatalities $\geq 4$ or life threatening illness or total permanent disability to a large exposed group (10 or more people)	Extensive permanent damage to endangered species, habitats, ecosystems or area/s of cultural significance  Extensive irreversible loss of community livelihood. Long-term social unrest and outrage	$> \$200m$	$> \$1b$	$> \$1.5b$	Multiple stakeholder groups confirming coordinated action, as reflected in media channels with significant reach and influence (eg. scheduled blockade or boycott covered in media for more than 1 week).	Criminal charges against any director or senior executive involving jail or loss of right to manage the company. Public inquiry – requiring considerable resources and Executive Management time. Loss of licence to operate an asset
	5 CRITICAL	1 – 3 fatalities or life threatening illness or total permanent disability to a small exposed group (<10 people)	Extensive long term partially reversible damage to vulnerable species, unique habitats, ecosystems or area/s of cultural significance  Extensive reversible loss of community livelihood. Prolonged community outrage.	$> \$50m - \$200m$	$> \$250m - \$1b$	$> \$375m - \$1.5b$	Multiple stakeholder groups mobilising and encouraging others to take action, as reflected in media channels with significant reach and influence (eg. social media campaign calling for protest, escalating over several days).	Criminal charges against any director, senior executive or senior manager not involving jail or loss of right to manage the company. Prolonged major litigation – exposure to significant damages / fines / costs. Suspension / restriction to operate an asset.
	4 MAJOR	Injury or illness to one or more persons, resulting in permanent partial disability	Long term reversible impacts to listed species, habitats, ecosystems or area of cultural significance  Significant impacts to community cost of living, business viability or social wellbeing. High levels of community tension.	$> \$20m - \$50m$	$> \$100m - \$250m$	$> \$150m - \$375m$	More than one stakeholder group's opinion or view influencing other stakeholders, reported through media channels with some reach and influence (eg. government comments in national media or in Parliament).	Criminal charges against any employee (not described above) Major litigation – exposure to damages / fines / costs.
	3 SERIOUS	Injury or illness to one or more persons resulting in hospitalisation, 5 or more days lost time or alternative / restricted duties for 1 month or more	Serious medium term reversible impacts to low risk species, habitats, ecosystems or area/s of cultural significance  Moderate impacts to community cost of living, business viability or social wellbeing. Moderate levels of community tension.	$> \$5m - \$20m$	$> \$25m - \$100m$	$> \$37.5m - \$150m$	More than one stakeholder group offering an opinion or view, reported through media channels with some reach and influence (eg. state based commentary lasting one 24 hour media cycle across internet, print, television, radio).	Non-compliance with conditions of licence to operate an asset or to conduct an activity. Litigation – exposure to damages / fines / costs.
	2 MODERATE	Injury or illness to 1 or more persons resulting in medical treatment, up to 5 days lost time or alternative / restricted duties for up to 1 month	Moderate short term impacts to common regional species, habitats, ecosystems or area of cultural significance Small scale impacts to cost of living, business viability or social wellbeing. Isolated examples of community tension.	$> \$1m - \$5m$	$> \$500k - \$25m$	$> \$750k - \$37.5m$	A single stakeholder group drawing attention to an incident, issue or approach, conveyed through media channels with potential reach and influence (eg. some social media complaints or local media reports).	Moderate non-compliance with external mandatory obligations or breach of contractual or other legal obligations (not described above). Litigation possible.
	1 MINOR	Injury or illness requiring first aid to 1 or more persons, or no treatment (record only)	Minor environmental or community impact - readily dealt with	$> \$100k - \$1m$	$< \$500k$	$< \$750k$	A person or organisation within stakeholder group signaling an interest in an incident, event or approach, using channels with limited reach or influence (eg. letter of complaint/commendation).	Minor non-compliance with external mandatory obligations or breach of contractual or other legal obligations.

\* Cash Flow - change from expectation over the life of the exposure. EBIT change from expectation over 12 – 18 month period.

**Figure 3.** Origin's risk matrix, which uses categories of impacts and measures of likelihood to classify risks from low to very high.

		LIKELIHOOD					
		1 REMOTE	2 HIGHLY UNLIKELY	3 UNLIKELY	4 POSSIBLE	5 LIKELY	6 HIGHLY LIKELY
		<1% chance of occurring within the next year. Only occurs as a '100 year event' or less frequent.	<10% chance of occurring within the next year. Could occur within decades.	<30% chance of occurring within the next year. Could occur within the next few years.	<60% chance of occurring within the next year. Could occur within months to years.	<90% chance of occurring within the next year. Could occur within weeks to months.	Likely to happen multiple times a year
	6 CATASTROPHIC	HIGH	HIGH	VERY HIGH	VERY HIGH	VERY HIGH	VERY HIGH
	5 CRITICAL	MEDIUM	MEDIUM	HIGH	VERY HIGH	VERY HIGH	VERY HIGH
	4 MAJOR	MEDIUM	MEDIUM	MEDIUM	HIGH	VERY HIGH	VERY HIGH
	3 SERIOUS	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH	HIGH
	2 MODERATE	LOW	LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM
	1 MINOR	LOW	LOW	LOW	MEDIUM	MEDIUM	MEDIUM

The application of Origin's risk matrix is mandated within Origin through its Risk Management Policy and Directive, which includes a risk rating toolkit that is utilised from the Board through to frontline activity owners (Figure 4). The toolkit takes into account the requirements of ISO 31000 and addresses risk identification, assessment and management.

## Origin Risk Rating Toolkit

### How to use this toolkit

#### Step A - describe the risk

Identify and describe the risk in terms of what could happen, its causes and potential effect/impact on Origin's objectives.

#### Step B - identify and assess controls

Identify and assess existing controls using the **Control Assessment Ratings**. Consider any related significant incidents, near miss events and assurance activities when assessing controls.

#### Step C - assess the level of consequence

Decide on the level of consequence that best represents the risk. Determine the highest credible consequence level in all relevant consequence categories in the **Risk Matrix**, taking into account current control assessment.

#### Step D - assess the likelihood of the risk

Determine the likelihood level in the **Risk Matrix** that represents the chance of the risk occurring at each consequence level identified, taking into account current control assessments.

#### Step E - determine a level of risk

Use the **Risk Matrix** to determine the level of risk.

#### Step F - determine the priority for risk treatment and approval

Using the **Risk Treatment and Acceptance Criteria**, determine the risk treatment required and who can approve/accept the risk at its current level.

#### Step G - assess the potential maximum consequences

Estimate the potential maximum consequence (plausible worse case level assuming all current controls fail) using the consequence categories.

Figure 4. Origin's risk management framework

In brief, the toolkit requires the regular assessment of underlying (unmitigated) risk from an activity, the residual risk once controls are applied, the effectiveness of controls and the likelihood and consequence of a risk event. A risk is either accepted in accordance with strict delegations of authority or the activity does not proceed.



## Control Assessment Ratings

Rating	Explanation
<b>Effective</b>	<ul style="list-style-type: none"> <li>▪ All controls are well designed and address the root cause/s of the risk.</li> <li>▪ All controls operate to the required level.</li> <li>▪ Ongoing monitoring required.</li> </ul>
<b>Can be improved</b>	<ul style="list-style-type: none"> <li>▪ Majority of controls are well designed and address the root cause/s of the risk.</li> <li>▪ Majority of controls operate to the required level.</li> <li>▪ Certain controls can be improved.</li> <li>▪ Ongoing monitoring required.</li> </ul>
<b>Needs to be improved</b>	<ul style="list-style-type: none"> <li>▪ Majority of controls are not well designed and do not address root cause/s of the risk.</li> <li>▪ Majority of controls do not operate to the required level.</li> <li>▪ Majority of controls require improvement.</li> </ul>

## Risk Treatment and Acceptance Criteria

Level of risk	Action required	Acceptance authority
<b>VERY HIGH</b>	<ul style="list-style-type: none"> <li>▪ Risk treatment must be in place immediately</li> <li>▪ Review risk quarterly at a minimum</li> </ul>	EMT member*
<b>HIGH</b>	<ul style="list-style-type: none"> <li>▪ Risk treatment must be considered (having regard to current business priorities)</li> <li>▪ Review risk annually at a minimum</li> </ul>	General Manager
<b>MEDIUM</b>	<ul style="list-style-type: none"> <li>▪ Risk treatment may be considered</li> <li>▪ Review risk two yearly at a minimum</li> </ul>	Group/Asset/ Project Manager
<b>LOW</b>	<ul style="list-style-type: none"> <li>▪ No risk treatment required</li> <li>▪ No ongoing review required unless determined by the relevant Group Manager</li> </ul>	Site/Activity Manager

\* Managing Director acceptance required for risks with a Catastrophic consequence and Likely or above Likelihood

When planning and risk assessing activities Origin applies the globally recognised principle of reducing process safety risk to ALARP (As Low As Reasonably Practical). ALARP is targeted through an ongoing process of hazard assessment (for seriousness of consequence as well as likelihood of occurrence) and risk reduction that starts during the concept and design phase of its activities, and continues throughout construction, operation and decommissioning (Figure 5).

**Figure 5.** Schematic representation of the ALARP principle.

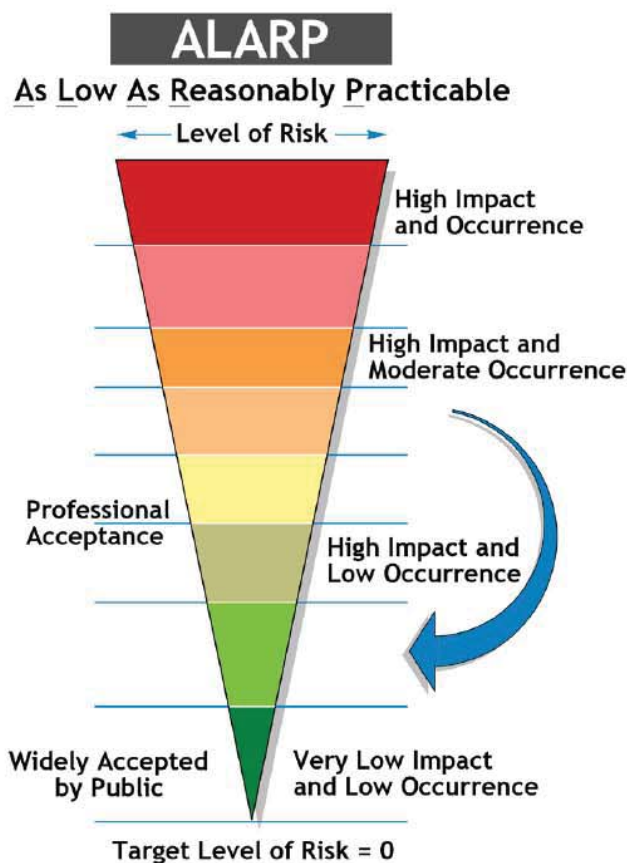
A risk can be considered to have been reduced to ALARP when all reasonably practicable control measures (both preventative and mitigative) have been identified and implemented to reduce the risk of identified events. A key element of demonstrating ALARP is that good practice is followed, where good practice is defined as the recognised risk management practices and measures that are used by competent organisations to manage well understood hazards arising from their activities.

This definition incorporates good practice as defined in codes and standards, and also a consensus of good practice within the industry. ALARP is not a final position over the life of an asset or project.

The practicability and the reasonability of control measures can change over time due to changes in technology (that can make measures more readily available or less expensive), industry standards (that can commoditise once-cutting-edge technology) and the socio-technical landscape (that can modify societal expectations).

Origin is cognisant of the stakeholder concerns associated with the risks of unconventional gas development and acknowledges that professional level acceptance of risk (Figure 5) can differ from thresholds for public acceptance. Origin is committed to improving the transparency and public understanding of its activities, through providing factual information about the risks and explaining the controls it applies to ensure its activities can be carried out safely and without unacceptable impact to the environment and community. Origin already shares all data from our groundwater monitoring program with the NT Government, and have committed to making it freely available to interested parties.

Detailed risk assessments require detailed project definition and activity descriptions. If large-scale development of shale gas in the Beetaloo progresses, then thorough Environmental Impact Statement (EIA) and Social Impact Assessment (SIA) processes would be completed.



## 2.2 Social impact risks

The Inquiry Terms of Reference (TOR) refer to several specific social-related issues, such as 'structures made or modified by humans', the 'amenity values of an area', 'economic, cultural and social conditions' and 'baseline health impact assessment'. These are examples of a larger set of potential social issues that are considered in this submission within a management system approach catering for all social-related contingencies. The described social performance management system also addresses the TOR request for "methods, standards and strategies" and how these can "effectively and efficiently reduce impacts or risks to acceptable levels".

In the context of social risks, this submission sets out in technical and managerial terms how externalities are thought about and managed in the extractive industry. Detailed analyses on specific risks are not included due to the remaining uncertainty regarding whether and what development might be feasible in the NT. The discussion on risk themes is intended to match the general terms of the Inquiry across the whole of the NT; however some explicit information and activities at Origin's Beetaloo Project are presented as examples of how acceptable social performance governance can be implemented.

In the risk language of the extractive industries, the TOR-referenced themes of Social; Aboriginal People and their culture; Economic; and Land Access are known as receptors. In this case, human receptors of potential benefits and impacts that could arise when extracting natural gas from shales using horizontal drilling and hydraulic fracturing. The language is important; extractive companies typically work with a management system approach on a source to pathway to receptor model; seeking to manage risk primarily at source, secondarily at pathway, and only in the rarest of circumstances falling back on receptor remedy and compensation.

The international risk management standard, ISO 31000, defines risk as the "effect of uncertainty on objectives". The risk-based thinking that arises from this definition means businesses take actions to reduce uncertainty of outcomes in all that they do. This risk management applies equally to reducing uncertainty to business and to stakeholders. ISO 31000 defines stakeholder as a "person or persons that can affect, be affected by, or perceive themselves to be affected by a decision or activity." Risk to stakeholders and risk to business are two sides of the same coin, meaning iterative and cumulative analysis considers potential benefits and negative impacts to both the business and its stakeholders. This is an important concept, accompanied by a set of analytical tools for reducing risk it means businesses regard managing risk to stakeholders as integral to their own success.

For example, industry risk analysis and management techniques have dramatically improved the health and safety performance of extractive businesses in the past two decades, to levels similar to or better than the retail sector. The approach is now being applied with equal efficacy to environmental and social performance. This safety example is not invoked as an appeal to stakeholders and regulators to 'trust us, we know what we are doing'; rather, it introduces a case for holding extractive businesses to account for externalities to its own highest standards of measurement and operational performance – 'don't just trust us, measure us'. Industry risk management approaches applied collaboratively with stakeholders, coupled with audits of regulatory compliance, provides for complementary layers of risk assurance.

Some of the descriptions and examples provided in this submission do not focus on specific NT locations, nor the risk themes from the perspective of receptors. Instead, the analysis focuses on the governance architecture that extractive businesses use to manage risk at the level of source and pathway. This does not diminish the centrality of receptors in risk management; rather it forces mitigation activity to happen where extractive businesses have real control on cause, well before effects occur in a chain of consequence.

### 2.3 Adaptive risk management

The Issues Paper identifies a number of broad and specific risks that could potentially be associated with the development of unconventional gas and the use of HFS in the NT. During a project impact assessment phase, significant work is undertaken to identify and assess risks and design and plan the appropriate mitigations. It is important that appropriate expertise and lessons from relevant similar projects are utilised to inform this work.

Accurately predicting a collectively exhaustive list of impacts, and understanding their likelihood and severity, is difficult before a project is defined in detail. The absence of full certainty, however, should not impede prudent development activity when undertaken with thorough risk assessments and applying the principles of 'adaptive management'. This principle ensures the appropriateness and effectiveness of impact management measures, and is continuously reviewed and adjusted based on changed circumstances and increased data quantity and quality. Without the application of this important principle, new projects where not all elements and data are known prior to commencement will never proceed.

Origin's project management processes uses the principles of adaptive management (i.e. learning by doing) to continuously improve knowledge of environmental risks associated with gas developments and target risk controls to ensure an acceptable level of impact. Adaptive management underpins the iterative process involved in translating environmental impact statement (EIS) commitments and environmental plan (EP) controls, and high level approval conditions.

For example our risk-based Disturbance Approval process guides environmental management decisions based on an assessment of environmental values, including:

- Noise (drilling and construction).
- Presence of:
  - > Environmentally Sensitive Areas (for example, threatened species habitat, conservation areas).
  - > Vegetation communities (condition of).
  - > Threatened flora. and
  - > Threatened fauna.
- Land Systems (susceptibility to erosion), and
- Proximity to waters (and values of the waters).

Key functions of an Environmental Disturbance Approval are to:

- Identify site specific environmental values.
- Obtain relevant secondary approvals.
- Develop work packs with management requirements, including hold points for various land disturbance activities, and
- Carry out assurance activities to validate compliance.

The following environmental assessment activities are typical:

- Ecological Survey involving desktop assessment and field survey to confirm vegetation communities, flora and fauna species, habitat values and areas of disturbance, generally at a property scale or defined area.
- Environmental Scout involving qualified professionals with environmental and cultural heritage experience to validate the disturbance footprint (and buffer) and optimise with regard to design principles, environmental constraints and heritage values. The scout includes:
  - › Water Features Assessment to validate mapped water features.
  - › Wetlands Assessment to validate mapped wetlands or if discovered during scouting.
  - › Springs Assessment to validate mapped springs or if discovered during scouting.
- Environmental Constraints Assessment where each aspect of the development footprint is reviewed against materially significant (environmental) aspects.
- Flora and Fauna Pre-clearance Survey to identify locations of conservation flora species, and active and potential breeding places to inform construction methodology.
- Targeted Weed Survey to provide baseline information for ongoing weed monitoring (at landholder request).
- Noise Assessment involving noise modelling to determine potential for nuisance at nearby sensitive places.
- Erosion and Sediment Control Plan to define temporary construction and permanent erosion controls for both linear and non-linear disturbance types.
- Construction Soil Management Plan to describe soil management measures for applicable soil types.
- Disturbance Project Management Plan as a checklist to consistently demonstrate compliance with statutory requirements and business systems.
- Environmental Workpack which details the site environmental conditions that will be encountered and the mitigation measures that are to be applied during construction.
- Environmental Hold Points which details the relevant environmental approvals and hold points required pre-construction, during site establishment and construction, and for completing the works.

A number of procedures, technical and work instructions, checklists and registers are documented through the approval process, which support execution and operations teams. The Environmental Disturbance Approval is also always read in conjunction with land access and cultural heritage approvals. The Environmental Disturbance Approval process is evidence of the principles of best available information and adaptive management working in practise to understand and mitigate risk.



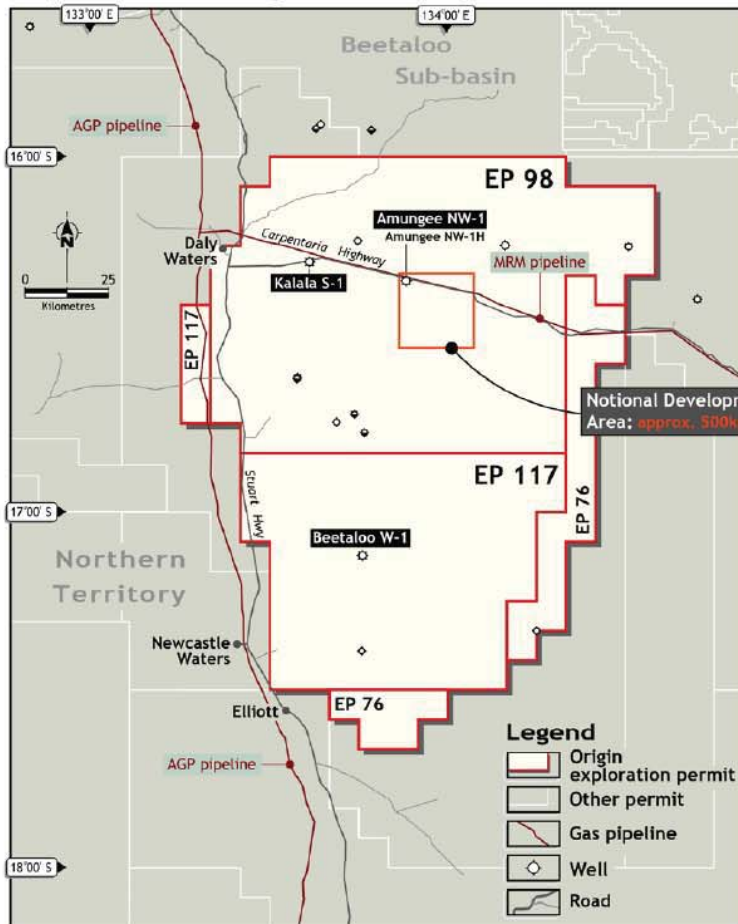
## 3 EXPLORATION WORK TO DATE AND DEVELOPMENT SCENARIOS

### 3.1 Exploration campaigns

Origin has completed exploration campaigns in 2015 and 2016 in the Beetaloo, drilling three vertical wells and one horizontal well to appraise the Velkerri and Kyalla formations (Figure 6). In addition to the drilling campaign, the multi-stage hydraulic fracture stimulation of the Amungee NW-1H horizontal well was completed in 2016. This operation represents the first horizontal stimulation operation in the Beetaloo. Data from the HFS operations and extended production test of the Amungee NW-1H are critical from a technical and, potentially, economic and political perspective.

These operations have provided a wealth of technical data to assist in the characterisation of the shale gas plays, as well as experience and data regarding operations specific to shale gas in the NT. In addition to the technical work program, Origin has also undertaken preliminary environmental baseline studies and substantial stakeholder engagement. Ensuring environmental baseline data are available is key to demonstrating that onshore natural gas developments can be undertaken without adverse environmental outcomes.

## Exploration Stage - Base Map



## A Exploration Stage

### Infrastructure

- Access roads
- Water bores

★ Primary Target (middle Velkerri)

☆ Secondary Target (Kyalla Formation)

Ma	Age	Lithology	Formation	Group
113-100	Cretaceous		Undifferentiated Cretaceous	-
	Cambrian		Anchony Lagoon Fm	Barkly Group
			Gum Ridge Fm	
505 ± 2 513 ± 12			Antrim Plateau Volcanics	
	Proterozoic		Bukalara Sst	Roper Group
			Chambers River Formation	
1106 ± 22 1086 ± 47 (maximum age)			Bukalorkm Sst	
			Kyalla Fm	
			Moroak Sst	
1354 ± 24 1349 ± 42 (maximum age)			Velkerri Fm	
		Dolerite		
			Bessie Creek Sst	

**Figure 6.** Permit and infrastructure map for the Beetaloo area including well locations, towns and communities (AGP = Amadeus Gas Pipeline and MRM = McArthur River Mine), and Regional stratigraphic column showing primary and secondary targets.



### 3.1.1 Drilling, hydraulic fracture stimulation and production testing

Origin drilled two vertical wells (Kalala S-1 and Amungee NW-1) and one horizontal well (Amungee NW-1H) in 2015, and one vertical well (Beetaloo W-1) in 2016. The range of total depths reached by the wells is summarised in Table 1. The Amungee NW-1H well was drilled from the intermediate hole section of the Amungee NW-1 vertical well, located in EP(98), close to the Carpentaria Highway (Figure 6). The Amungee NW-1H lateral section was landed and drilled through the 'B Shale' of the middle Velkerri (Figure 7).

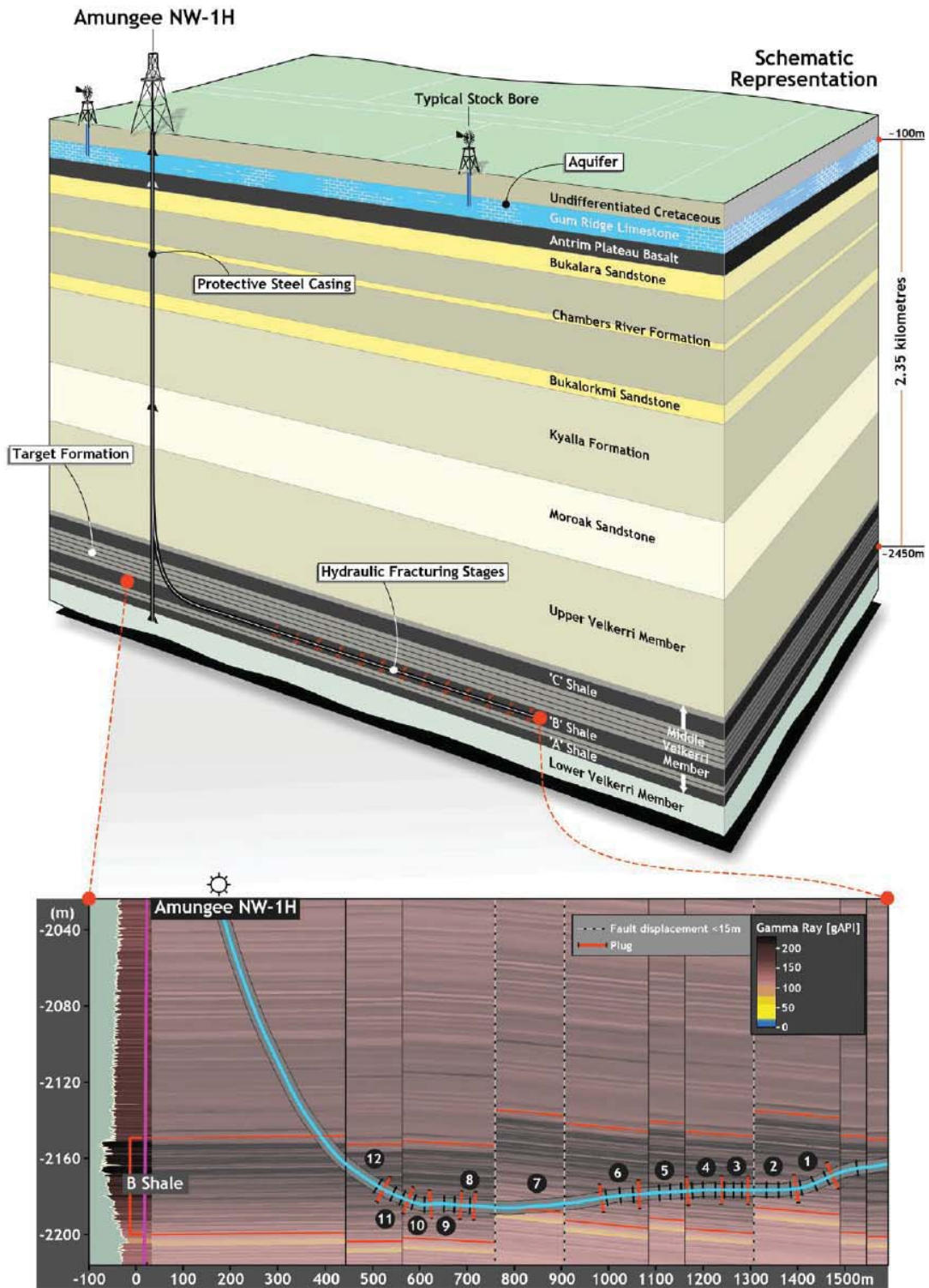
WELL	DRILLING COMMENCED	# DAYS	TOTAL DEPTH	COMMENTS
Kalala S-1	14/07/2015	50	2,622mTVD	Well cased and suspended for future testing.
Amungee NW-1	7/09/2015	44	2,609mTVD	Well partially abandoned in preparation for sidetrack.
Amungee NW-1H	28/10/2015	27	3,808mMD 2,428mTVD	Attempted to case well unsuccessfully. Suspended well for re-entry next dry season.
Amungee NW-1H Re-Entry	16/06/2016 (Ops Begin)	26	3,808mMD 2,428mTVD	Well cased and suspended for future fracture stimulation.
Beetaloo W-1	22/07/2016	54	3,172mTVD	Well cased and suspended for future testing.

**Table 1.** A summary of wells drilled by Origin in 2015 and 2016.

TVD = True Vertical Depth and defines the depth in a purely vertical sense below the reference point, which is typically the rig floor some 4-8 metres above ground level.

MD = Measured Depth and defines the total distance in any trajectory away from the reference point. MD is equal to TVD for a perfectly vertical well but in deviated wells MD is always greater than TVD.

Field preparation for hydraulic fracture stimulation (HFS) operations at Amungee NW-1H commenced in June, 2016, when double-lined, above-ground ponds were constructed for water storage. Sub-surface operations began in July when the cement bond log was carried out to confirm the integrity of the cement emplacement completed prior to the well suspension at the end of drilling operations. Then, from 25 August to 8 September, 2016, a total of 11 HFS stages were pumped into the Amungee NW-1H lateral section, effectively placing 2.5 million lbs of proppant and 10,640 m<sup>3</sup> of fluid.



**Figure 7.** The Amungee NW-1H well lateral section was landed and drilled through the 'B Shale' of the middle Velkerri approximately 2.3 km below the Cambrian Limestone Aquifer.

Months of planning and preparation went into ensuring the safe and successful execution of the Amungee NW-1H HFS, which was executed with no recordable safety or environmental incidents and which met all technical objectives. Table 2 summarises the key steps, time taken and the extensive process to go from concept to execution for the Amungee NW-1H HFS operations.

PROJECT PLANNING		
1	Stimulation Services RFT Issued	09/03/2016
2	Contracts Awarded	01/06/2016
3	DFIT (CBL) Program Rev2 Origin Approved	26/07/2016
4	Stimulation Program Rev1 Origin Approved	27/07/2016
5	HSE Management Plans & ERPs	05/07/2016
6	Environmental Plan Rev1.2 Origin Approved	12/07/2016
REVIEW AND APPROVALS		
7	Application for CBL	25/07/2016
8	DPIR CBL Approval	28/07/2016
9	Application for DFIT	05/08/2016
10	DPIR DFIT Approval	10/08/2016
11	Application for Stimulation	05/07/2016
12	DPIR Stimulation Approval	23/08/2016
13	Application for Well Suspension	04/11/2016
14	DPIR Well Suspension Approval	17/11/2016
WATER SOURCING		
15	Water procurement	01/08/2016 - 07/09/2016
CONFIRMATION OF WELL INTEGRITY		
16	Cement Bond Log	29/07/2016
17	Casing Pressure Test	21/08/2016
WELL INJECTIONS AND COMPLETIONS		
18	DFIT	25/08/2016
19	Stimulate 12 stages	26/08/2016 - 08/09/2016
20	Drill out bridge plugs	10/09/2016
21	Flowback / wellbore cleanup	11/09/2016
22	Set production packer	29/09/2016
23	Run production Tubing	02/10/2016
PRODUCED GAS AND WATER HANDLING		
24	Commence Test	04/10/2016
25	Shut in well	30/11/2016
WATER DISPOSAL		
26	Produced Fluids removed from location	18/11/2016 - 01/12/2016

**Table 2.** Summary of HFS operations at Amungee NW-1H.

An extended production test (EPT) was completed at Amungee NW-1H following HFS. The initial production, as measured over the first 30 days (following the production tubing installation) was 1.11 million standard cubic feet per day (MMscfd) and the average production rate over the EPT was 1.10 MMscfd, with a final production rate of 1.07 MMscfd (Table 3). These production rates are encouraging without being categorical proof of commerciality; further improvements to gas rates will be required to prove commerciality. Increasing the length of the lateral section is a technically achievable means of increasing rate, and has been demonstrated to increase production rates (based on North American analogues)

PHASE	CUMULATIVE GAS PRODUCED (MMscf)	CUMULATIVE LOAD FLUID RECOVERED (m <sup>3</sup> )
Clean-up	5.6	970
Extended Production Test	63.0	990
Total	68.6	1960 (18% of total pumped volume)

**Table 3.** Summary of the cumulative gas produced and flowback fluid recovered during the clean-up and EPT phase in Amungee NW-1H.

### 3.1.2 Health, safety and the environment

Origin is proud of the health, safety and environment (HSE) performance throughout the campaigns with no environmental or worker health and safety consequences.

As required by the NT Petroleum Act, and enforced through the Department of Primary Industry and Resources (DPIR) activity authorization application process, all activities are undertaken with the following activity specific plans in place:

- Environmental Management Plan (Table 4)
- Health and Safety Management Plan
- Oil Pollution Emergency Plan
- Emergency Response Plan

The Environmental Management Plan (EMP) sets out how Origin has assessed the environmental and social conditions, in which the activities will be undertaken based on recent field and desktop studies, which then feeds into identifying the risks that will be encountered. The plan then details how these risks will be mitigated and how the activities will be undertaken in a way which reduces these risks to as low as possible.

EMP NAME	EMP APPROVED	ACTIVITY
Hydraulic fracture stimulation and well testing	23/8/2016	HFS and testing of Amungee NW-1H
Exploration drilling (2016)	30/6/2016	Drilling of: Beetaloo W-1
Exploration drilling (2015)	30/6/2015	Drilling of: Kalala S-1, Amungee NW-1, Beetaloo C-1 (not drilled)

**Table 4.** Approved Environmental Management Plans submitted by Origin (<https://dpir.nt.gov.au/mining-and-energy/public-environmental-reports/reports-for-petroleum-operational-activities>).

The Health and Safety Management Plan details the actions that are taken to ensure that work is undertaken at the highest level of safety with the goal of achieving zero harm. In the case of an accident, the Emergency Response Plan details how this would be dealt with. In the last two years, other than for regular drills, Origin's Emergency Response Plans were only used to help respond to incidents involving the general public, such as vehicle accidents, unrelated to Origin's work. Finally the Oil Pollution Emergency Plan details the response to any form of hydrocarbon release, including of methane.

A summary of all incidents during the 2015 and 2016 exploration campaigns is included in Appendix 1. Over this two year period, 57 incidents occurred. Fifty-five of these were classified as minor with no ongoing environmental or worker health and safety consequences. The reporting and recording of every minor incident and near-miss is important for Origin's HSE systems which use minor incidents as leading indicators so we can learn and actions can be taken early to correct processes and behaviours, and prevent future incidents. For instance, we detected twice in one month, through in-vehicle monitoring systems, that drivers were not wearing seat belts. These incidents did not occur on public roads but rather in vehicles moving a short distance in camp. However, their reporting enabled us to emphasise driver safety and that there are no exceptions to the use of seat belts in a moving vehicle under any circumstances.

Of the two incidents that received a rating higher than minor, neither was associated with HFS operations. The first non-minor incident occurred when a portable building became unsecured from a flat-bed truck onto which it was being loaded. Although no one was injured, and no damage incurred, this was classified as a near miss because of the potential for a more serious safety and material damage outcome and triggered a safety incident investigation.

The second incident was classified as moderate (2) on a five-point scale from minor (1) to catastrophic (5). In this incident, salt contained in a drilling sump that had been backfilled at the end of the campaign migrated into the lease area. During the design of the drilling sumps, modelling indicated there was no risk to ground water from salt contained within the pits. In early 2016, after construction and use of the sumps, Origin became aware that there may be a shallow perched aquifer in the area. To confirm the presence of the system, three shallow monitoring bores were installed near the lease pad area. The bores confirmed that a previously unknown, shallow, seasonal system exists. It is not suitable for water production. However, the Risk Assessment to ground water was modified to reflect these new data, and the response actions amended to include further monitoring and investigation.

Additional shallow monitoring bores across the lease area in late January detected salt migration into the lease area at shallow depths – no impact has been detected at shallow monitoring bores off lease or in the Cambrian Limestone Aquifer (CLA) (even on lease) and there are no likely pathways to the CLA. The DPIR was notified and further monitoring, data gathering, and modelling are underway. Investigation results to date indicate that there is no perched, seasonal system at the other well sites and that salt has not migrated significantly from the sump location at Amungee NW-1H and remains well contained within the lease. All activities are being undertaken with the approval of the regulator and Origin will work with landholders and the regulator to ensure any required remediation is completed.

### **3.1.3 Results and outcomes (contingent resources)**

The successful exploration campaigns, which culminated in the EPT at Amungee NW-1H, allowed Origin to announce a discovery to the NT Department of Primary Industry and Resources (DPIR) in October 2016. As required by the NT Petroleum Act (2016) a Discovery Evaluation Report was subsequently submitted to the DPIR in February 2017, which provided more detail of the discovery. Simultaneously to the DPIR submission, Origin announced a 6.6 TCF Contingent Resource (Origin, 2017) to the Australian Stock Exchange (ASX). The knowledge gained from the 2015-16 campaigns and the Amungee NW-1H discovery allow us to map out hypothetical development scenarios.

## 3.2 Development scenarios

Although the viability of gas development in the Beetaloo is still uncertain, it is useful to define stages of activity required to reach development and describe a potential development scenario to assist in discussion of the Risk Themes identified in the Issues Paper. In each phase, outlined below and in Figure 8, key data would be acquired across the Core Area of the Beetaloo (Figure 1), as risks are investigated, and the quality of the opportunity better understood – allowing staged and measured investment and project expansion.

Activities undertaken during each phase of exploration and development is similar, however, the scale increases as certainty of project viability increases. Communicating how activities are completed and how they could impact stakeholders is important in building open and trusting relationships. Origin accepts its responsibility to share information openly, and we have included our Community Guide to CSG Activities in Appendix 2 as an example of the detail that Origin provides to communities where we are active. This document provides details regarding working with landholders and environmental management that are relevant in a much broader range of contexts than Queensland CSG alone.

### 3.2.1 Appraisal phase

Prior to committing to a development, more thorough appraisal of the Beetaloo is required. The appraisal phase (Figure 9) will be focused on assessing the commerciality of the Amungee NW-1H discovery to make an informed decision on whether to proceed with further delineation of the project. This means that Origin must achieve positive gas deliverability results while improving well costs over a sufficient area to underpin a future development (including the infrastructure costs to tie it into markets).

The appraisal phase of the project will require between eight and 16 wells drilled on between two to six pads and will likely occur over two to three years. Origin will need to strike a balance between evaluating well deliverability over a material area and demonstrating cost performance through pad drilling. Origin is considering options to use capacity in existing pipelines in order to test the wells and avoid flaring. Additional infrastructure such as compression and basic gas processing may be required, depending on gas composition.

### 3.2.2 Delineation phase

The delineation phase (Figure 10) would comprise a small scale development pilot with a target egress capacity of 50 to 100 terajoules per day (TJ/D). This small scale development will occur on a subset of the area evaluated during the appraisal phase. The delineation phase will utilise multi-well pads (notionally 8 wells per pad) to demonstrate operational efficiency improvements and cost optimization. It is estimated that this phase will require between 24 and 48 well drilled on three to six pads over a two to four year timeframe.

The gas may be used to supply NT demand and/or fill capacity in the Northern Gas Pipeline to the east coast gas market. Such a scenario requires new pipeline infrastructure to tie into the existing Amadeus Gas Pipeline (AGP) and will likely require an expansion of the existing compressor station and gas processing equipment to handle the larger volumes.

By the end of the delineation phase there should be sufficient understanding of well deliverability, resource materiality, and well cost to conduct a robust commercial assessment of the project. This will inform the decision about whether to proceed to full development, and define an appropriate scale of development.



### 3.2.3 Development phase

If the project proceeds to development, it could proceed on a range of scales.

#### 3.2.3.1 Small Scale Development

A small scale development (Figure 11) would simply be a continuation of the delineation phase of the project with development occurring as necessary to fulfil local supply requirements. A 20 to 40 year project with an egress capacity of 50 to 100 Terajoules Per Day (TJ/D) would require 50 to 100 wells drilled on 6 to 12 pads. This option would not require infrastructure other than the infield gas gathering system and would utilize the same regional infrastructure as the delineation phase to tie into the AGP pipeline.

#### 3.2.3.2 Large Scale Development

A large scale development (Figure 12) would require new pipeline infrastructure to be built to bring the volumes required to market. A new pipeline to reach Darwin or east coast markets would require a notional egress capacity between 400 to 500 TJ/D to meet the scale of development in this scenario.

This development option would require between 400 and 500 wells drilled on 50 to 65 pads over a 20 to 40 year period. Additional infield infrastructure expansions, such as gas gathering systems and gas plant, would be required. However, even for this level of development and scale of gas recovered, a relatively small total project footprint of approximately 500 km<sup>2</sup> is required (Development Area), with a directly affected surface area of <10 km<sup>2</sup> or 2% of that (Figure 13b). This activity could be located entirely across a single pastoral station, given the limited area required and the large area covered by the pastoral stations in the area. Origin considers that it is unlikely more than four landholders would host gas infrastructure (excluding any potential regional pipeline expansion) for the notional large scale development described here.

During peak production (Figure 13a) the notional development could have up to 57 well pads active, with each pad comprising of eight wells. The stimulation of these 456 wells would be staggered over approximately 24 years. Average annual total water usage is forecast at 1,200 ML/year of which we forecast 30% is recycled and, therefore, approximately 840 ML/year of groundwater is required (Figure 13c). Peak total water usage, including recycled flowback fluid, for drilling and stimulation is forecast at 2,600 ML approximately 7 to 10 years into a large scale development (Figure 13c).

The Cambrian Limestone Aquifer (CLA) is the principal water resource in the basin; the sustainable yield from the Georgina Basin (which includes the CLA) is estimated to be in the order of 100,000 Megalitres Per Year (ML/year) (NALWTF, 2009). Existing groundwater use in the Beetaloo Basin is estimated at 6,000 ML/year or 6% of the sustainable yield (Knaption and Fulton, 2015). An additional ~840 ML/year groundwater usage (on average) would increase the projected extraction from the CLA to ~6.8% of the estimated water resource available from the CLA in the Georgina Basin.

After the field has been fully developed (i.e. all the well locations have been drilled) the field transitions from development to a harvest phase. During the harvest phase wells are produced until the end of their economic production life (20 to 30 years after development). At the end of the harvest phase a field transitions to the rehabilitation phase. During this final phase, wells would be plugged and abandoned, lease pads reclaimed, and pipelines decommissioned.

### 3.2.4 Minimizing disturbance through multi-well pads and horizontal drilling

Multi-well pads and horizontal drilling substantially reduce the footprint of unconventional developments. From a single surface location (i.e. a pad) Origin can develop an area of between 7 km<sup>2</sup> to 12 km<sup>2</sup> depending on the lateral lengths and spacing of the wells. Chapter 15 provides aerial imagery from shale gas fields in Ohio showing the small surface footprint in the developed area as a result of multi-well pads and horizontal drilling.

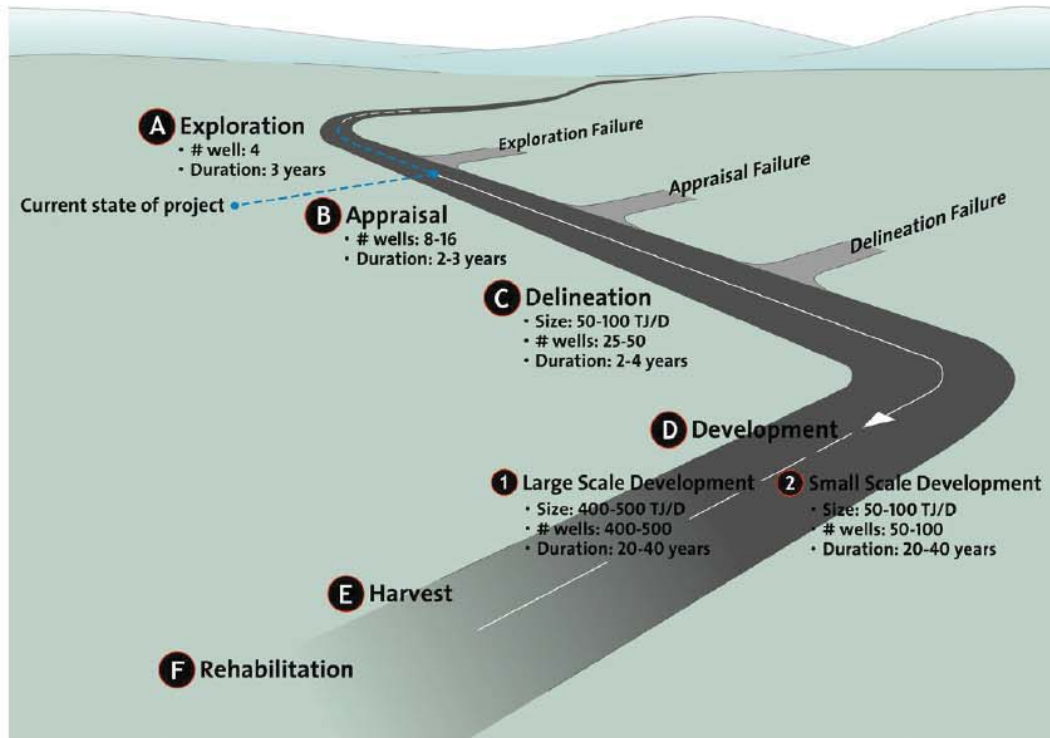
Origin's notional design is for an eight well pad with 3km horizontal laterals spaced 400m apart (Figure 14). As horizontal drilling technology continues to improve the lateral lengths will likely continue to increase<sup>2</sup>, resulting in even fewer pads being required within the notional Development Area (Figure 15).

The eight well pad is designed to exploit a single target (i.e. the Velkerri B-Shale). If multiple targets were to be exploited (e.g. both the Velkerri B-Shale and the Kyalla Formation) the pad design could accommodate 16 wells without increasing the pad surface area. If two targets proved to be viable the notional Development Area and number of pads required to support a 400-500 TJ/D development would be approximately halved.

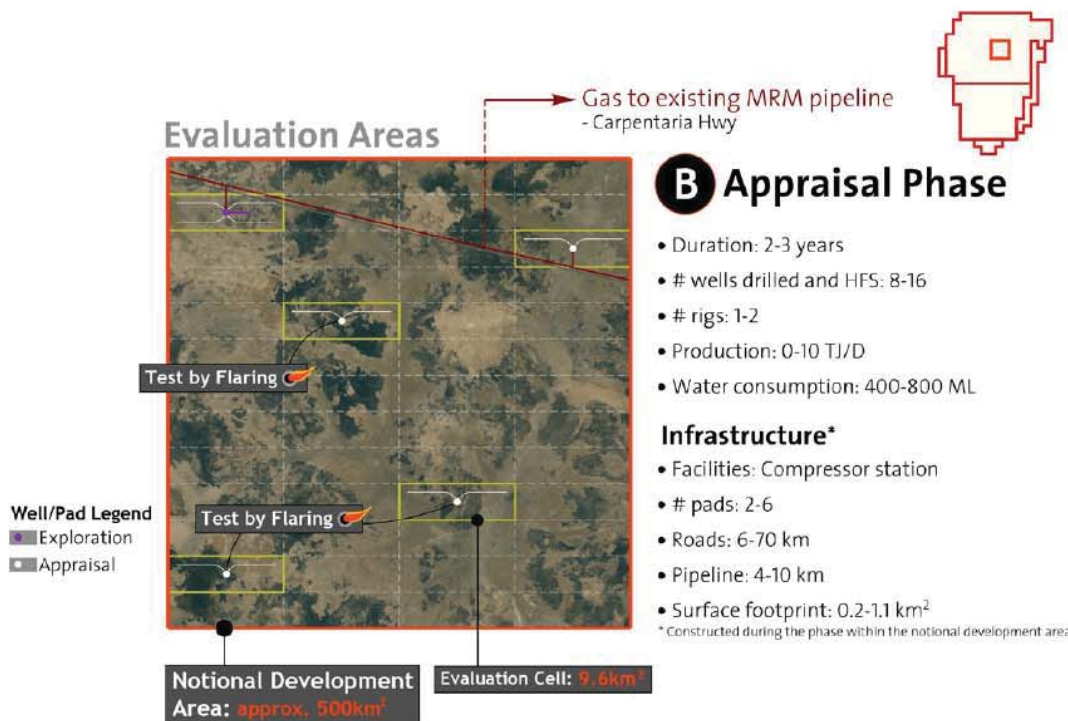
Each pad is connected by a road and pipeline. Multi-well pads and horizontal drilling not only reduce the number of pads required but also the kilometres of pipeline and road required. By contrast, tight gas and CSG fields that have been developed with single well pads require more roads and pipelines over an equivalent Development Area.

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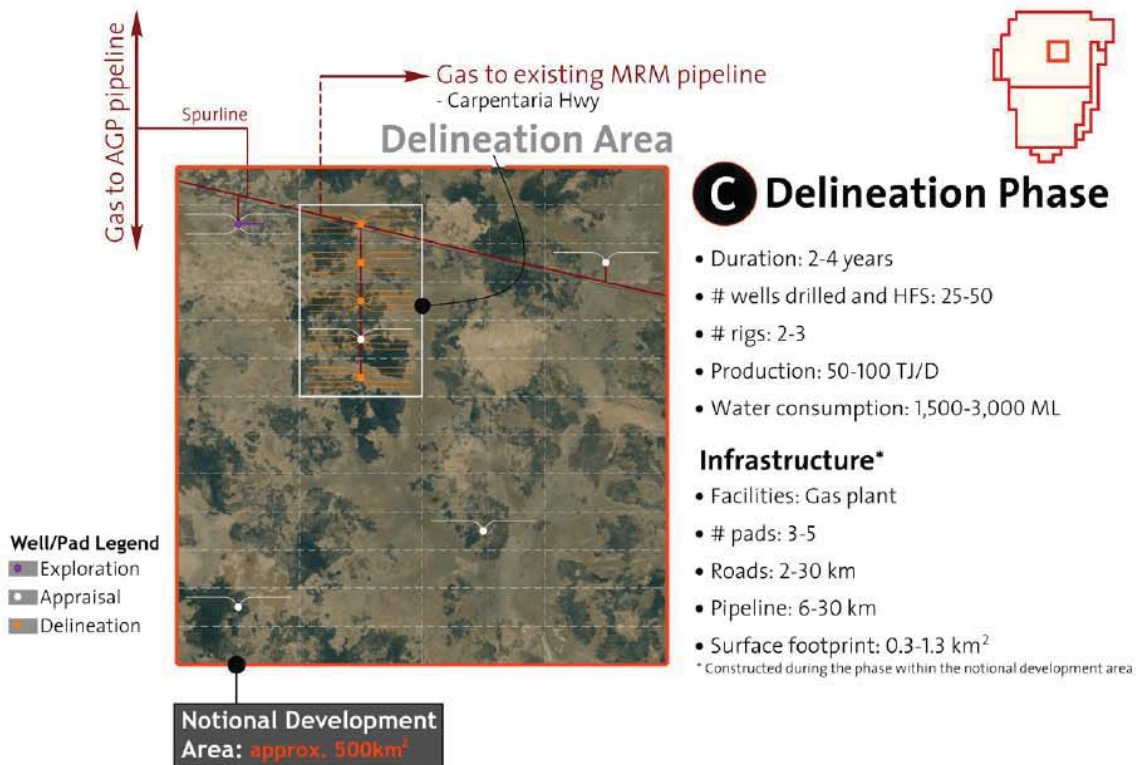
<sup>2</sup> Eclipse Resources' Purple Hayes well in the Utica had a lateral length of 5.6km (<https://www.oilandgas360.com/shale-record-is-eclipse-resources-124-stage-purple-hayes-well-the-longest-onshore-lateral-ever-drilled/>)



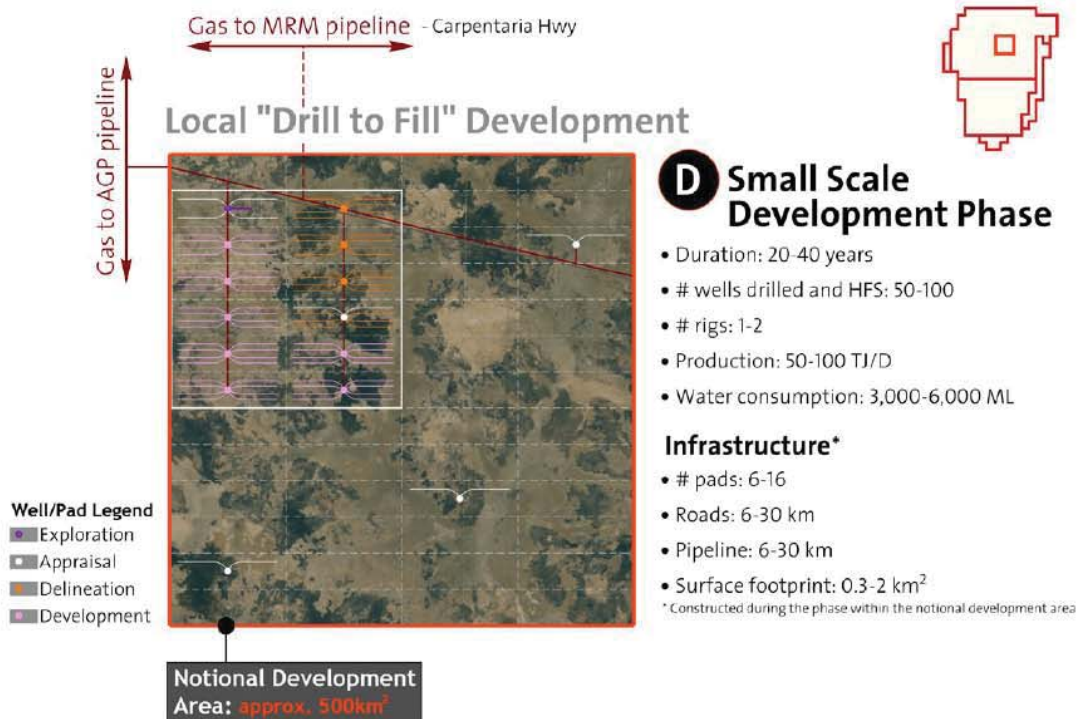
**Figure 8.** Schematic representation of project phasing in gas developments, with specific estimates of activity for a notional development in the Beetaloo.



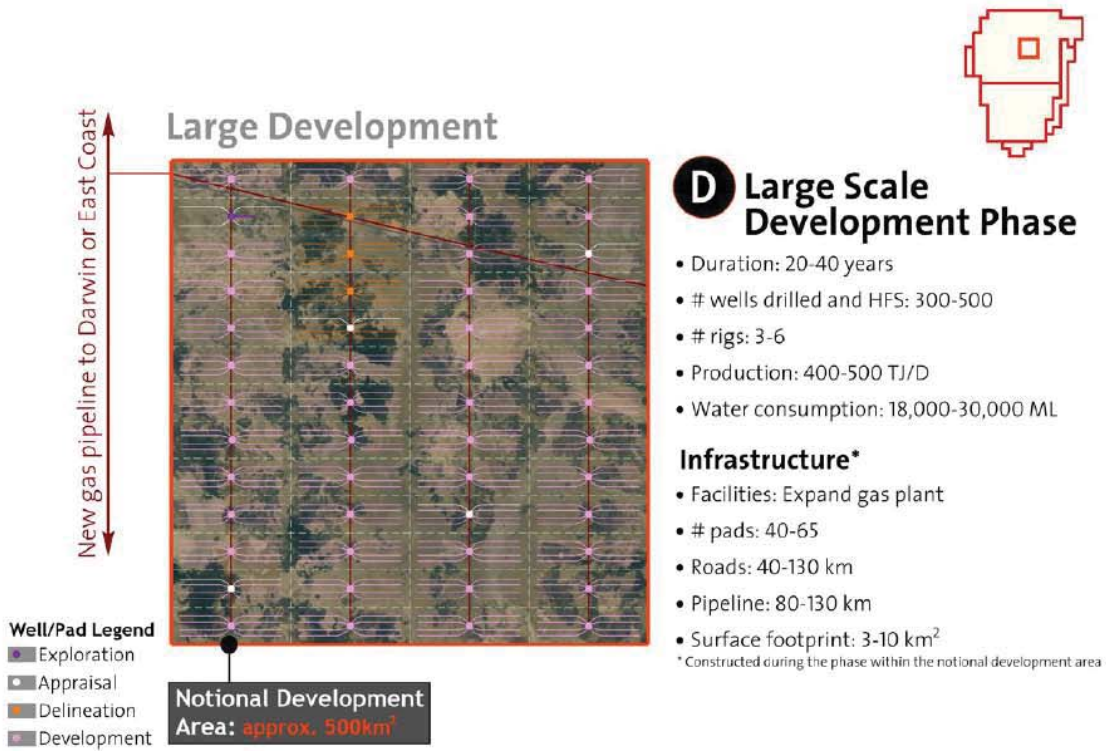
**Figure 9.** Schematic representation of an appraisal phase project including key activities and infrastructure statistics.



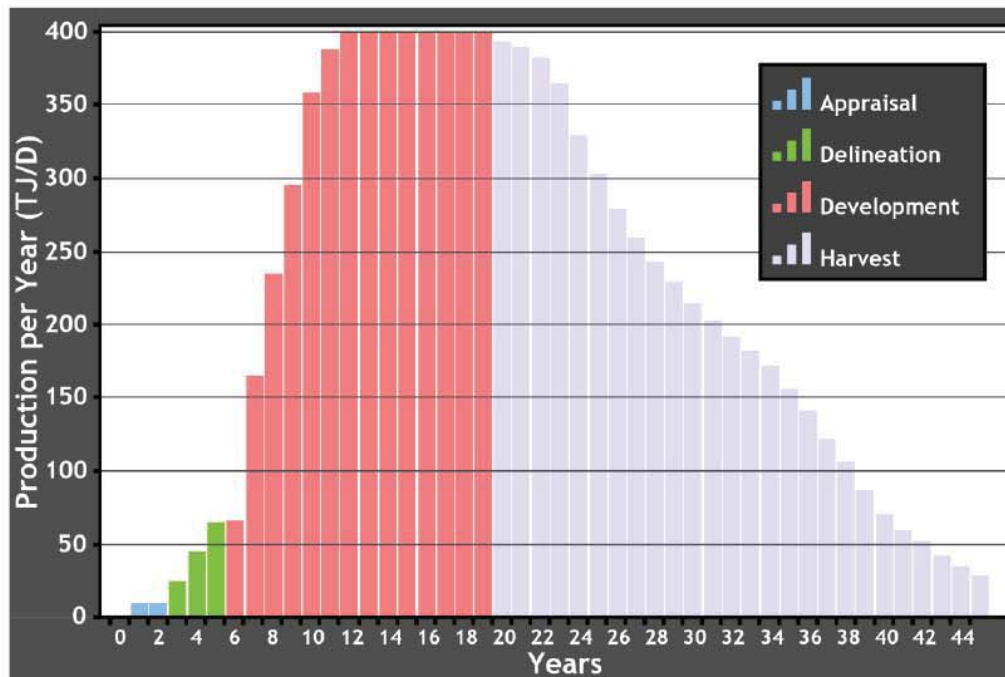
**Figure 10.** Schematic representation of a delineation phase project including key activities and infrastructure statistics.



**Figure 11.** Schematic representation of a relatively small scale development project including key activities and infrastructure statistics.



**Figure 12.** Schematic representation of a large scale development project including key activities and infrastructure statistics.



**Figure 13.** a.) Large scale development production by year.

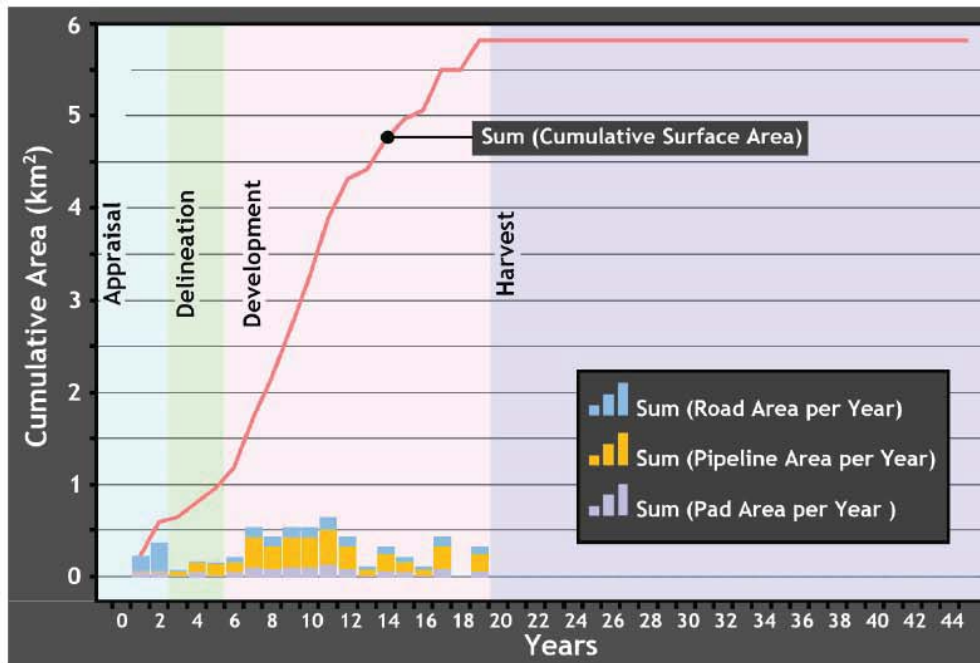


Figure 13. b.) Large scale development surface area footprint by year.

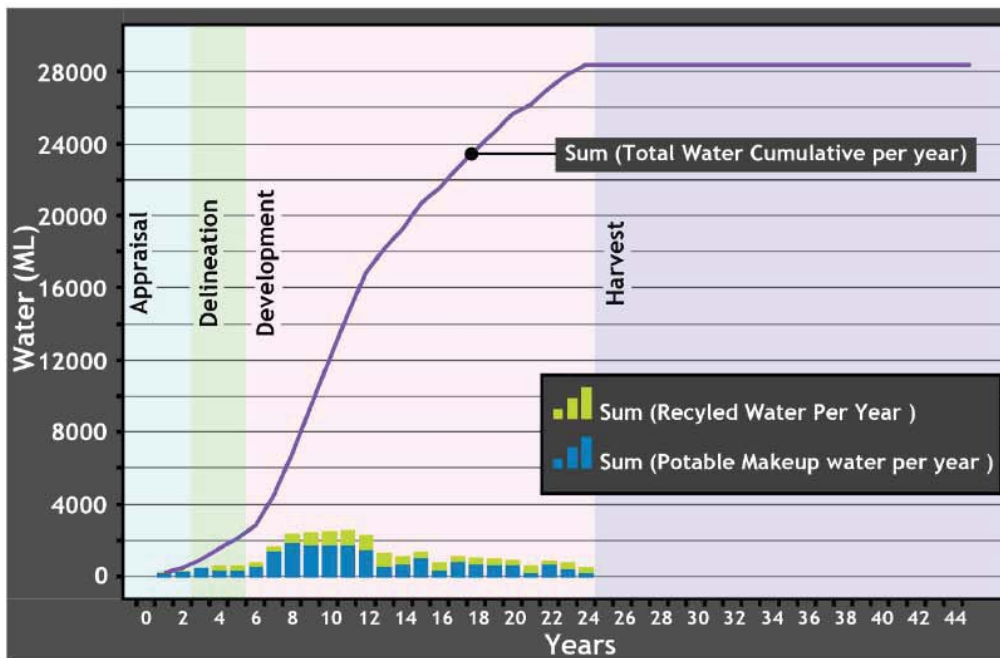
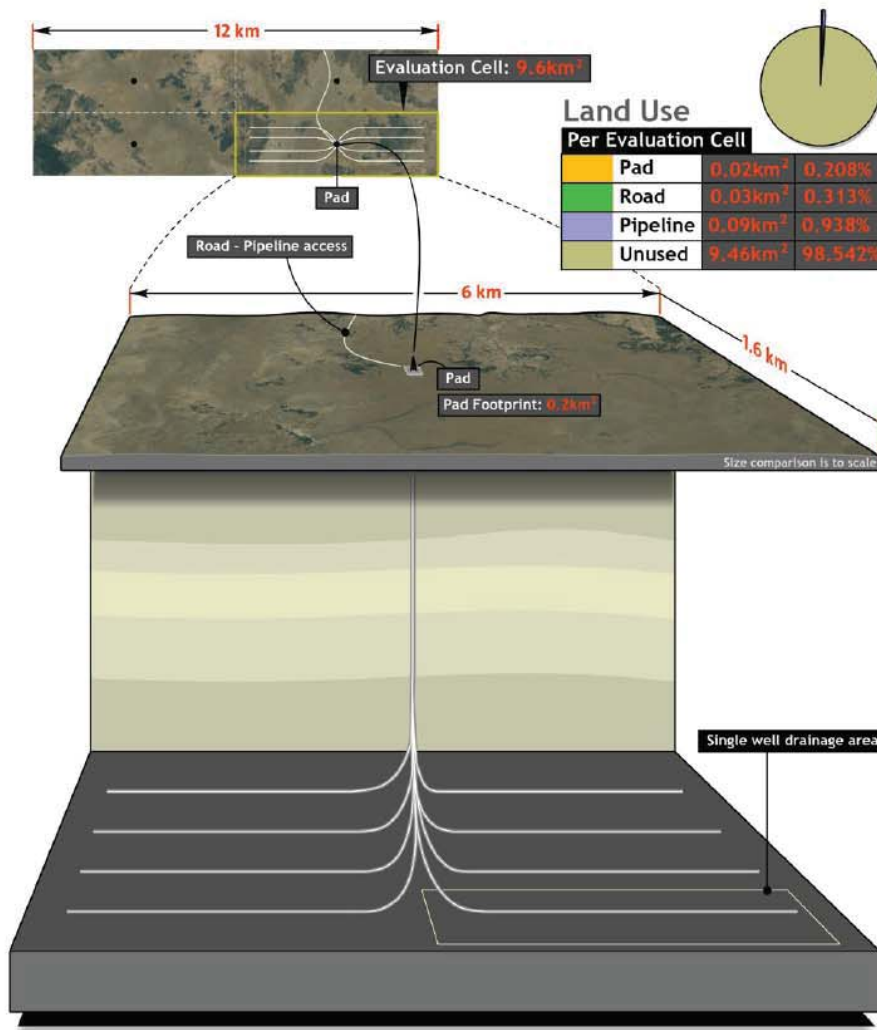
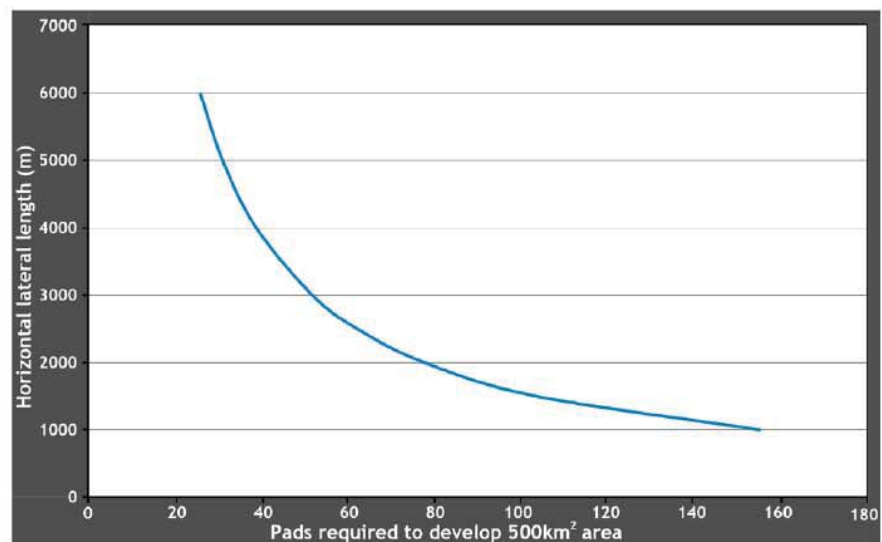


Figure 13. c.) Large scale development water usage by year.



**Figure 14.** A scaled schematic of a multi-well pad with horizontal wells, which illustrates the minimal surface impact for a large subsurface footprint.

**Figure 15.** A plot of horizontal well lateral length vs number of well pads for a 50 km<sup>2</sup> Development Area illustrates the benefit of longer lateral wells in terms of minimising surface impacts.



### 3.2.5 Development Area physical geography

The Beetaloo region is sparsely inhabited with a population estimated at less than 1000. Significant settlements occur along the Stuart Highway at Elliot and Daly Waters. Pastoral leasehold accounts for over 90% of land use within the area with the remaining tenure including Aboriginal Land Trusts and freehold, Crown Land and small conservation reserves. The Study Area (Figure 1) occurs over three bioregions: the Stuart Plateau Bioregion, the Mitchell Grass Bioregion and the Gulf Falls and Uplands Bioregion. The area has a semi-arid climate with average rainfall ranging from 665 mm in the north of the basin to 518 mm in the south. Rainfall is linked to the north Australian monsoon and falls almost exclusively between December and March. The topography of the Basin is dominated by the flat-lying Sturt Plateau and the Barkly Tablelands in the south. Surface drainage is limited in these areas and waterways only flow briefly in response to heavy rainfall. Lake Woods, a large ephemeral lake in the south of the study area, is the most notable drainage feature. To the north-east of the basin a more substantial surface water system drains towards the Gulf of Carpentaria (Knapton and Fulton, 2015).

For the purposes of subsequent chapters and assessments of risk, the Development Area, as defined above, covers an area of 500 km<sup>2</sup> (20 km by 25 km) in the core area of the Permits and is representative of the natural environment and physical geography (notionally between Amungee Mungee, Shenandoah and Beetaloo stations). Construction of well pads, roads and pipelines would occur within this area if development was to proceed, disturbing a small portion of the Development Area (Disturbance Area). The small number of landholders that would be directly impacted by a gas development contrasts with the experience of operators in Queensland where hundreds of landholders are directly impacted.

We use different terms to describe the areas affected to different degrees by development:

- Disturbance Area: The total land area within the Development Area which will be disturbed by vegetation clearing with or without soil disturbance.
- Local Scale: See Development Area.
- Regional Scale: The Regional Scale for the purposes of risks to land is considered to be the Bioregion within which the Development Area falls.

### 3.2.6 Development Area human geography

The Permits straddle several hundred kilometres of the Carpentaria and Stuart highways and their junction at Daly Waters, a small service settlement on the western permit boundary. The settlement of Elliot (population of 355; Census 2006) lies just outside the southwest boundary of the Permits, likewise the map locality of Newcastle Waters. The towns of Tennant Creek (pop. ~ 8000) and Katherine (pop. ~9,200) are located 200 km south and north respectively on the Stuart Highway. The Aboriginal Traditional Owners of the region, the Jingili, primarily reside in Elliot, Newcastle Waters, Daly Waters and a 5 by 5km Aboriginal Freehold block called Jingaloo to the east of the Stuart Highway. In total an estimated 1000 people comprising equal numbers of people of Aboriginal and non-Aboriginal descent live on or close to the boundaries of the Permits.

Beetaloo's human geography is a good example of the sort of social landscape that might host a shale or tight gas development in the NT. Given the very early nature of Origin's work to date, its social performance activities have been limited in scope and engagement has been focused on those people living on or close to the Permits. An interim Baseline Socioeconomic Assessment was completed in 2015, restricted to a desktop study of population, residency, livelihood and well-being characteristics drawn from Australian Bureau of Statistics sources.



The study focused on the three local government areas in the project's area of influence, giving an early picture on age profiles, labour participation rates, housing and transport infrastructure, health and education facilities and the type of social issues that are prevalent in the region. Typical of early exploration stage desktop studies, it does not provide detailed social performance planning. Such planning can only occur once projects progress to a scoping stage of investigation. To date social risk analysis has been conducted for exploration activities with mitigations designed and implemented accordingly.

### **3.2.7 Development project scale and scheduling – guiding workforce planning**

Origin has learnt from experience as upstream operator of the APLNG project in Queensland, where it was one of three proponents constructing mega-projects simultaneously in the same basin. The challenges some communities have faced in terms of the boom and then bust are very real, and have left mixed feelings about the impact of the gas industry in some communities. On balance the economic and social impacts in southwest Queensland are positive, but there is more work to do to support the regional economies and ensure broader community benefit. We know we can do more to create local opportunities and grow regional capacity, whilst also utilising existing local and indigenous business to support our activities.

We recognise that if a development proceeds in the Beetaloo area, there will be a need for a greater number of workers than could be supplied locally or even regionally. This would then lead to a population increase, an increase in a combination of drive-in/drive-out or fly-in/fly-out (DIDO or FIFO) workforce, or both. Origin commits to planning its workforce to manage this in a way that provides opportunities for local and regional residents, and positively impacts the region.

One of the natural limitations on the more extreme boom/bust cycles associated with other large-scale gas development projects around Australia is that Origin does not anticipate the construction of greenfield LNG facilities to support a development in the Beetaloo. Australia's existing export capacity in the NT and Queensland and current supply-demand forecasts suggest that there will be substantial demand for NT gas in the east coast domestic gas market and from exporters with long term contracts that require a reliable supply.

There are other existing limitations on the scale and rate at which a development in the NT could proceed. The existing pipeline capacity from onshore basins in the NT to either Darwin or the east coast is limited to relatively low volumes (for example the Amadeus Gas Pipeline, which runs from Mereenie in the Amadeus Basin to Darwin, can transport approximately 104 TJ/day only). Hence, for a large scale development to proceed, multiple pipeline routes would require expansion and this would limit the rate at which wells would be drilled in a development for five to 15 years.